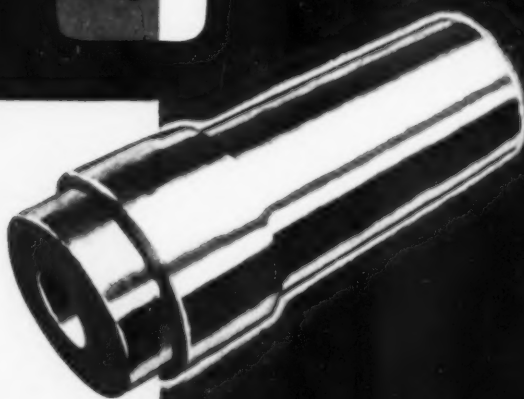
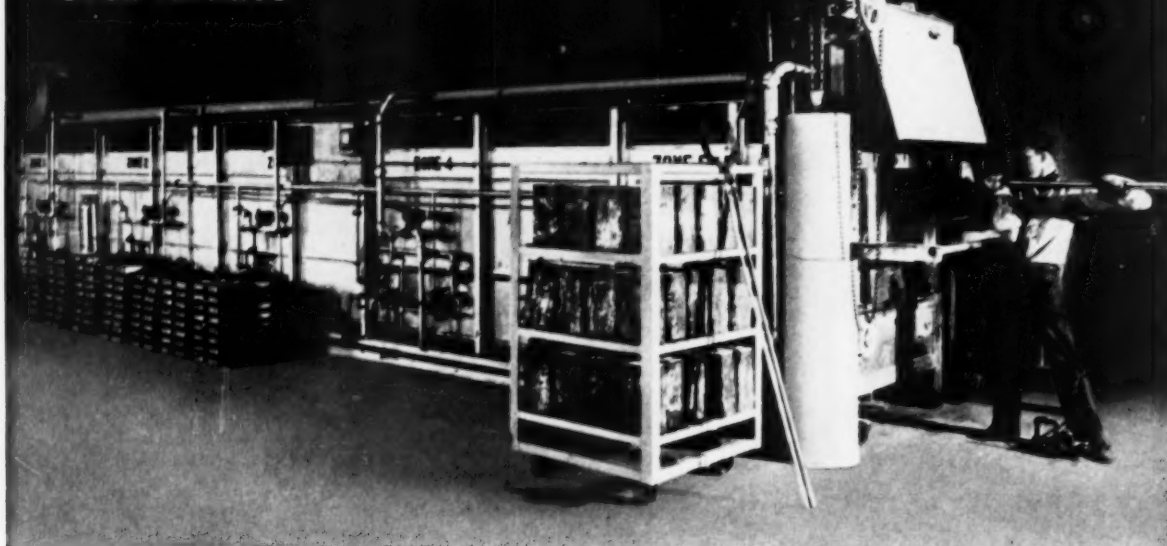


metal progress



continuous oven furnace



speeds investment mold heating with closer control

Investment casters speed up production and eliminate the risks of distortion, cracking, and excessive mold expansion during burnout operations with 'Surface' double-end, pusher-type, large oven furnaces.

There are 5 good reasons for this:

1. uniform heating. No rejects due to spotty heating. This is a result of 50 years of combustion engineering behind 'Surface' equipment.

2. time-temperature cycle control. 'Surface' furnaces are zoned to provide the time-temperature cycle required for your process.

3. simple burner control. The one-valve control of 'Surface' burners makes it simple to achieve a combination of zones of oxidizing and neutral atmospheres.

4. fuel economy. Automatic-proportioning burners save fuel by assuring correct gas-air ratios.

5. equipment for any requirements. Whatever your flask sizes or work volume, there is 'Surface' Standard-Rated equipment to handle the job.

Units up to 40 feet long now in use. 'Surface' furnaces pay off for investment mold heating at low cost. Write for Literature Group H54-9.



SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING **Janitrol** AUTOMATIC SPACE HEATING

Metal Progress

September, 1954

Vol. 66, No. 3

Cover by Don Arnstine

Black Light Inspection

Ernest E. Thum, *Editor*
Marjorie R. Hyslop, *Managing Editor*
John Parina, Jr., *Associate Editor*
Floyd E. Craig, *Art Director*

Engineering Articles

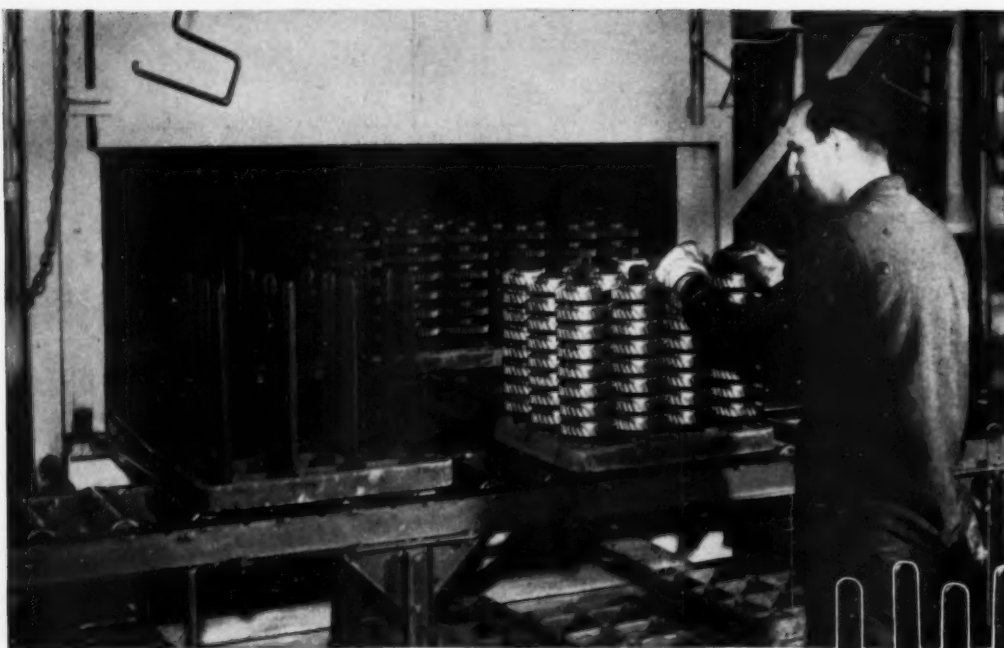
- Brittle Failure of Steel Structures — a Brief History, by M. E. Shank** 83
Although 250 welded ships have been disabled since 1940 by brittle cracking, such failures began as soon as steel plate became available for structural use and include storage tanks, bridges, booms and long pipe lines.
- Metallurgy in the Days of Alchemy, by Carl Andrew Zapffe** 89
In "Light Metallurgy" in last November's issue, R. P. Lister suggested that alchemical gibberish was due to contrasting urges—the scientist's urge to publish and the industrialist's urge to secrecy. Carl Zapffe now shows that some of the alchemical "principles" were not so erroneous. For example, change "phlogiston" to "energy" and the theory makes sense to physical chemists.
- Linings for Induction Furnaces, by H. E. White** 99
Magnesia-alumina mixes and zircon are now favored for special steels and high alloys. The author presents many "do's" and "don'ts" for the melting superintendent, and backs up his advice with facts about properties of the minerals and the refractory manufacturing processes.
- Automatic Zinc Plating, by C. E. Fisher and D. F. Zlatnik** 107
Procedures and equipment used at Riverbank Ordnance to plate cartridge cases.
- Aluminum in France, by T. L. Fritzlen** 113
Meeting, exposition and plant visitations in a centenary celebration of Deville's production of aluminum metal show that the French use of aluminum in automobiles (consuming one fifth the total output) is on a much greater scale than in America.
- Induction Surface Hardening of Ductile Iron, by Joseph F. Libsch and Joseph C. Danko** 115
Ductile or nodular cast iron, heat treated by quench and temper or isothermally to structures containing considerable combined carbon, can be case hardened by rapid induction heating to about C-57, with case depths somewhat greater than steel.
- Sigma Phase—a Review, by Adolph J. Lena** 122
Sigma can be identified by microscopic methods and by X-ray analysis of the bulk material or the concentrated phase. Sigma occurs in many binary and ternary systems, some of which compose the high-temperature alloys.
- Book Reviews**
- "Jet, the Story of a Pioneer" and "Development of Aircraft Engines and Fuels"**
reviewed by E. E. Thum 96
The first is almost exclusively devoted to Whittle's homeric struggle to develop jet propulsion for fighting aircraft, while the second gives a more complete picture of the aeronautical, mechanical and metallurgical details of jet engine developments on an international scale.

Table of Contents Continued on Page 3

Copyright, 1954, by AMERICAN SOCIETY FOR METALS, 7301 Euclid Ave., Cleveland 3, Ohio. Published monthly except bi-weekly in July; subscription \$7.50 a year in U.S. and Canada; foreign \$10.50. Single copies \$1.50; special issues \$3.00. Entered as second-class matter at the Post Office in Mt. Morris, Ill. . . . The AMERICAN SOCIETY FOR METALS is not

responsible for statements or opinions printed in this publication. . . . Requests for change in address should include *old* address of the subscriber; missing numbers due to "change of address" cannot be replaced. Claims for nondelivery must be made within 60 days of date of issue. No claims allowed for overseas subscribers.

SEPTEMBER 1954; PAGE 1



They heat treat 50 different types of gears . . .

with one type of THERMALLOY* TRAY



Thermalloy tray and fixtures with adapter in place to give different loading pattern. Spacers at right.

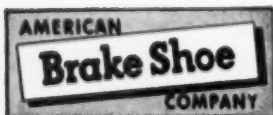
A large automotive parts manufacturer processes over 50 different types of gears in a carburizing-oil quench furnace where temperatures range to 1700°F. A heat-treat tray design was needed to withstand rugged service...to give maximum loading for all gears.

Here's how Electro-Alloys developed a versatile tray to meet these conditions:

First: Electro-Alloys engineers designed a type of tray and set of fixtures to handle this wide variety of gears. This was accomplished by supplying adapters and spacers to supplement the basic tray design. With this adaptability, fewer trays were needed . . . less handling time was required in heat treating the variety of gears.

Second: Trays, fixtures, adapters, spacers . . . all were cast in Thermalloy . . . a tough heat-resistant alloy developed specifically to take heavy loads and rough usage . . . to withstand elevated temperatures up to 2100°F. without scaling or cracking. This tray takes loads up to 315 lbs. per tray . . . has been in service for over 13 months.

Electro-Alloys has helped engineer many types of heat-treat parts and has cast them in Thermalloy for longer life. Why not put this knowledge to work for you . . . call your nearest Electro-Alloys office or write Electro-Alloys Division, 5002 Taylor Street, Elyria, Ohio, for a copy of Thermalloy Tray & Fixture Bulletin T-227.



ELECTRO-ALLOYS DIVISION
Elyria, Ohio

*Reg. U. S. Pat. Off.

Table of Contents Continued

Critical Points

Toolsteel Mill in Canada, by the Editor.....	81
Some metallurgical items of interest uncovered during inspection of the new London, Ont., plant of Vanadium-Alloys Steel Co.	

A New Steel for Pressure Vessels, by the Editor.....	82
--	----

Carilloy T-1 resembles the triple-alloy steels developed during the war, but with other elements added to give it some 77 qualifications, chief among them being excellent weldability without preheat or stress relief, good impact strength, ductility and bendability in all directions, low temperature of transition from ductile to brittle fracture.

Data Sheet A New Numbering System for Wrought Aluminum Alloys.....	112-B
--	-------

A four-digit index system similar to the S.A.E. numbering system for steels, adopted by the Aluminum Assoc., as of Oct. 1, 1954. Conversion tables show equivalents in the old system.

Digests of Important Articles

Lubricants for Nonferrous Metalworking	144
Report of informal discussion held by the Metallurgical Engineering Committee of the Institute of Metals.	

Vitreous Enameling Keeps Pace With Production Practices	146
Preparation of enamel, types, application of ground and cover coats, defects.	

Castings for Aircraft	152
The Air Forces has contracted for design and pilot plant production and testing of castings to replace forgings for parts such as landing gear trunnions.	

Some Factors Which Affect Quality of Iron Ore Sinters.....	156
Thin-section radiography leads to new observations on structure and properties.	

Review of Problems in Resistance Welding Coated Steels.....	162
Pointers on welding steels coated with cadmium, lead, tin, aluminum and zinc.	

Internal Stresses in Forgings Minimized With Slow Cooling.....	164
Uniform slow cooling is inefficient, but a gradually increasing cooling rate will reduce internal stress and still reduce time in the furnace.	

Character of Oxide Scales on Titanium.....	172
Investigation of products formed by reaction of pure oxygen on titanium at 1110 to 1700° F.	

Scope of Application for Subzero Treatments.....	174
Refrigeration for force-fit assembling, delaying age hardening of aluminum, cooling tool edges, stabilizing size of gages, and correcting deficient quench hardening.	

Commercial Feasibility of Titanium Castings.....	176
Although commercial shaped titanium castings are at least several years away, a sound metallurgical basis exists on which a titanium castings industry can be built.	

Welding, Metallurgy and Design in British Shipbuilding.....	180
A review of factors that contribute to brittle fracture of ship plate.	

Zirconium Additions Inhibit Grain Growth in Extruded Al.....	188
Coarse grain can also be controlled by modifying conditions of extrusion, by additional hot work, or by modifying the heat treatment cycle.	

Research in the United States.....	194
The European researcher is more inclined to fundamental or laboratory research; the American concentrates on "development"—the paying project.	

Steel Cartridge Cases.....	198
Twin Cities Arsenal makes 45-caliber cases of steel or brass at same rate.	

Replacement of Mo by V for High-Tensile Steels.....	200
Lower transition temperature and higher proof stress without impairing weldability.	

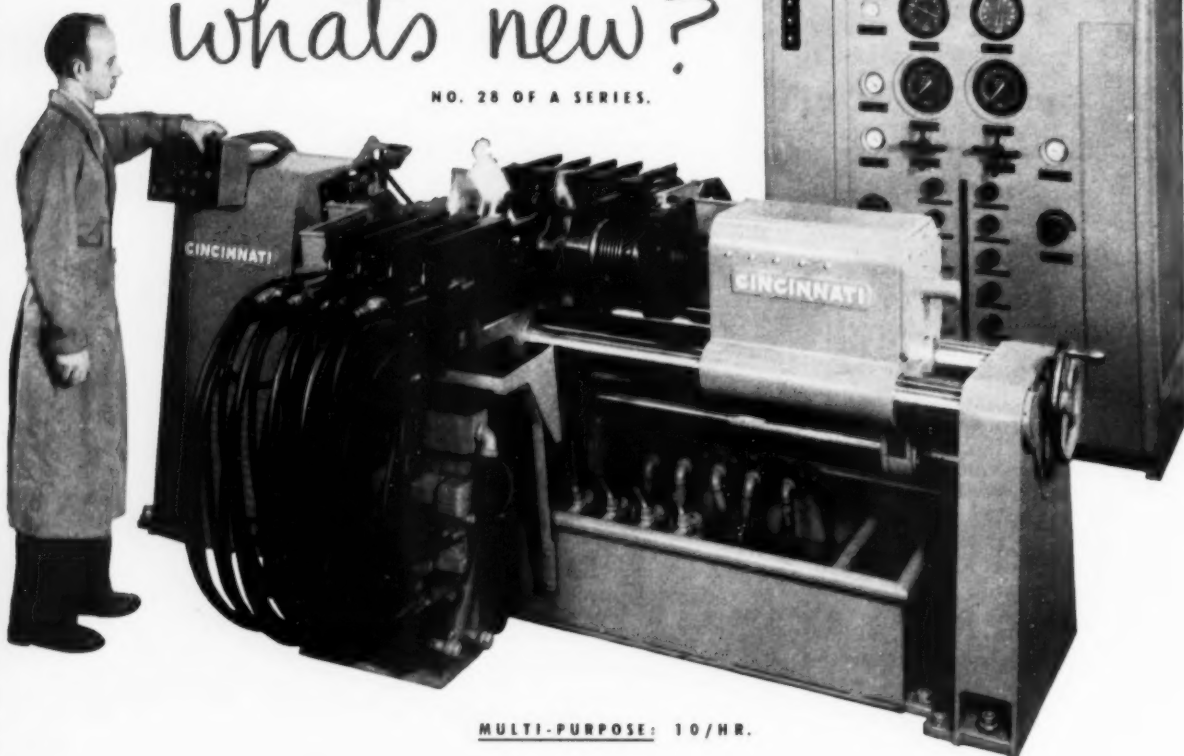
Departments

As I Was Saying, by Bill Eisenman.....	5
Personals	130

Engineering Digests of New Products.....	13
Manufacturers' Literature.....	21
Advertisers' Index.....	224

what's new?

NO. 28 OF A SERIES.



MULTI-PURPOSE: 10 / HR.

flamatic hardens crankshaft bearings

10 / hr. to 70 / hr.

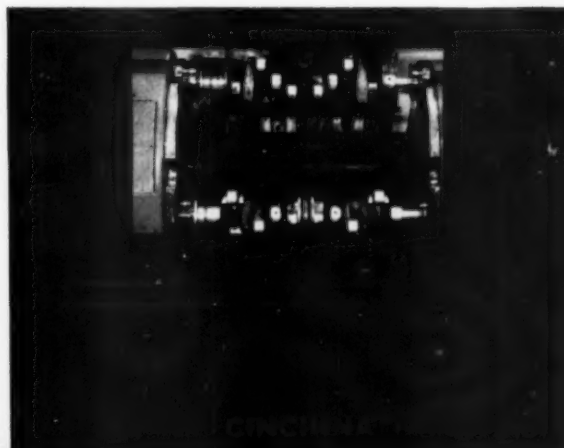
It's no wonder that the automotive industry turns to **flamatics** for selective heating precision. One of the many reasons is the automatic **flamatic** which hardens all 9 main and pin bearing diameters of a crankshaft in one operation. Designed for one size and type of workpiece, this machine averages 70 units/hr. Another reason is the **flamatic** shown above, which provides the flexibility required for small lot production runs or development work on a variety of crankshafts. Interchangeable flame heads, adjustable flame head holders, and adjustable tailstock make it easy to change from one size of crankshaft to another.

Average production: 10 units / hr.

Single- or multi-purpose **flamatics** have met production requirements on many other parts—gears, spindles, cams, pliers, etc. More reasons for specifying **flamatic** are described in new Flamatic Catalog, Publication No. M-1861.



SINGLE-PURPOSE: 70 / HR.



flamatic

PROCESS MACHINERY DIVISION

THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U.S.A.

As I was saying...



THE SUMMER MONTHS are the warmest and busiest of the year for the home office of the A.S.M. When all other ASMembers (so I'm told) are taking a vacation it's probably just as well for us to be busy. "Well, Bill, what keeps you busy?" I seem to be always hearing someone ask. So I'll hedge a little and let you in on a fact you may have already realized—it is that I don't do very much myself. I just delight in acting as a straw boss (you can knock me over with a feather) and I keep jotting down things the staff should do tomorrow and the next day and then see that the list of things to do is circulated to all concerned.

While this job of mine, sometimes called "ridin' herd", may sound like a heck of a Simon Legree activity, it's indeed a pleasant one, since I believe I have beyond all doubt the best congregation of dedicated ASMembers ever assembled in the service of 24,000 members. I've been fortunate to gather around me a group of experts who know more about the subjects they have to deal with than I do and I am might happy that is so. It makes for accomplishments that give credit to the Society.

Would you believe it—we are now preparing floor plans and details for the Philadelphia Show in October '55, and have just confirmed dates for the Metal Show in '58 and expect to close on '59 dates sometime next month. Just this month we assigned spaces (94% sold) for the Western Metal Exposition in the Pan-Pacific in Los Angeles, March 28 to April 1, 1955. The Chicago Show, Nov. 1 through 5 of this year, with the seminar starting on Saturday and Sunday preceding, has been given its finishing touches. The technical papers will all be preprinted and distributed by Sept. 15. The Official Program and the convention issue of *Metal Progress* (October) have been planned and are now almost ready for bed. Many new features will be inaugurated for the Chicago Show. Watch the program and announcements carefully. With the Show another S.R.O., we have been able to devote all our time to planning: 1) to increase the interest in the program; 2) to bring more interested manufacturing personnel to the Show. Unless all signs go to the contrary, both these endeavors will be successfully accomplished.

I have just returned from a jaunt through the East and had the pleasure of meeting with the chairmen and vice-chairmen of more than 35 chapters. At these meetings the agenda included the following: technical programs, meetings, education, membership, student affairs, public relations, Science Achievement Awards and others.

If anyone should ever ask you what is "the spark" that has made a leader in the field of engineering societies, you will be 100% correct if you answer, "The spark is supplied by and really is the wholehearted acceptance of their responsibilities by the members elected as the executive committees and officers of the chapter. They tackle the assignment with a spirit and determination for success that brooks no opposition and overcomes every road block. Their enthusiasm is contagious and the splendid leadership they display fires all the members to greater achievements. That's the Spark that lights the road to Progress and Success."

Cordially yours,

Bill

W. H. EISENMAN, Secretary
AMERICAN SOCIETY FOR METALS

Interested in
improved safety
on metal cleaning
operations?



Solventol research has recently developed a new Series of Di-Phase Metal Cleaners which give more protection in both dip and spray cleaning operations. These improved cleaning materials now have a new high flash point minimum of 210°F. plus, making possible the following important advantages:

1. Much safer operation.
2. Less solvent loss.
3. Greater savings.
4. Improved cleaning efficiency.
5. Improved temporary rust protection.

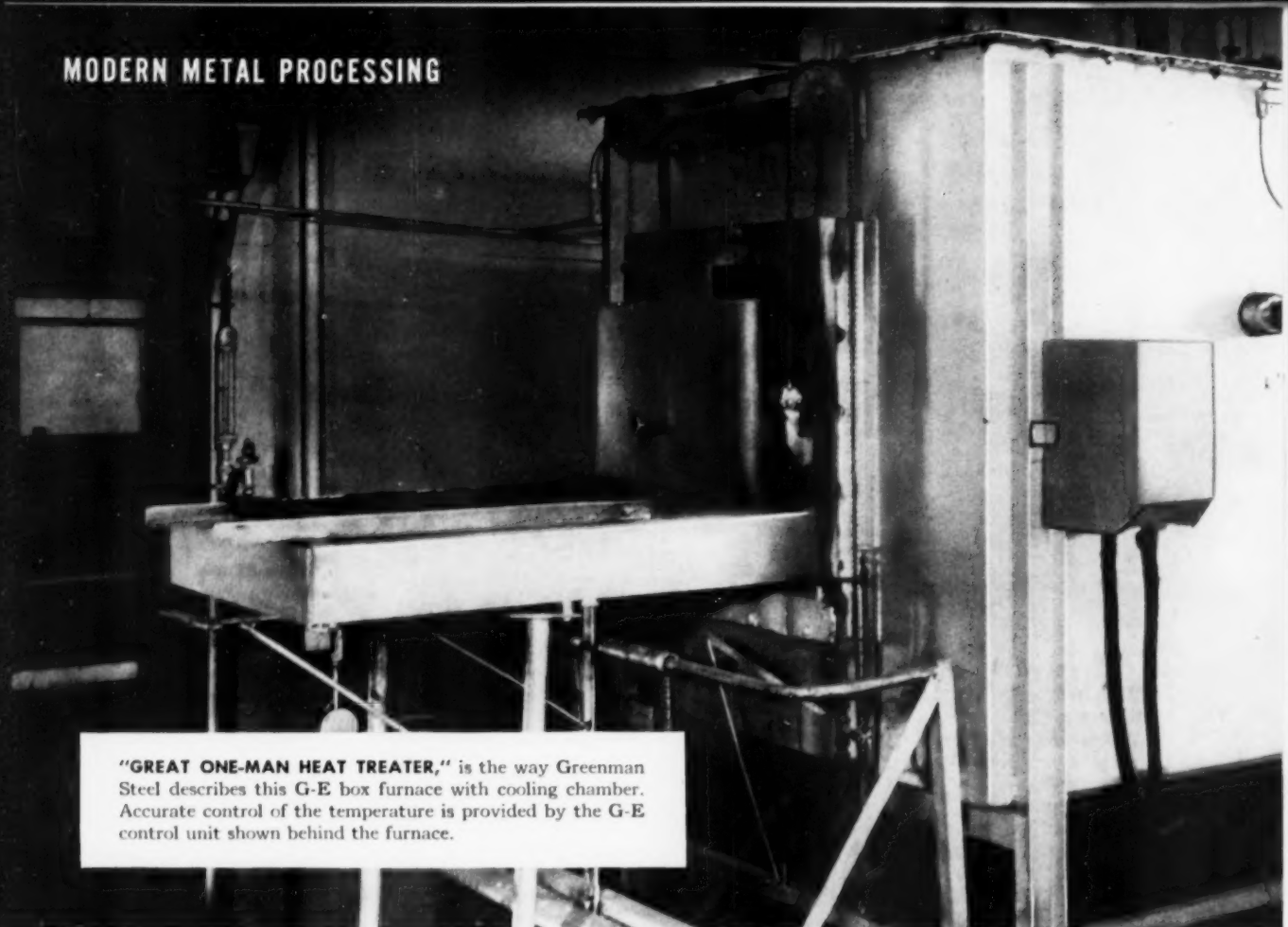
SOLVENTOL
DI-PHASE
METAL CLEANING

SEND TODAY for technical specifications and descriptive literature on the NEW Solventol Di-Phase Liquid Series of Metal Cleaning Compounds.

SOLVENTOL CHEMICAL PRODUCTS, INC.
DETROIT 3, MICH. PH. TOWNSEND 8-8466

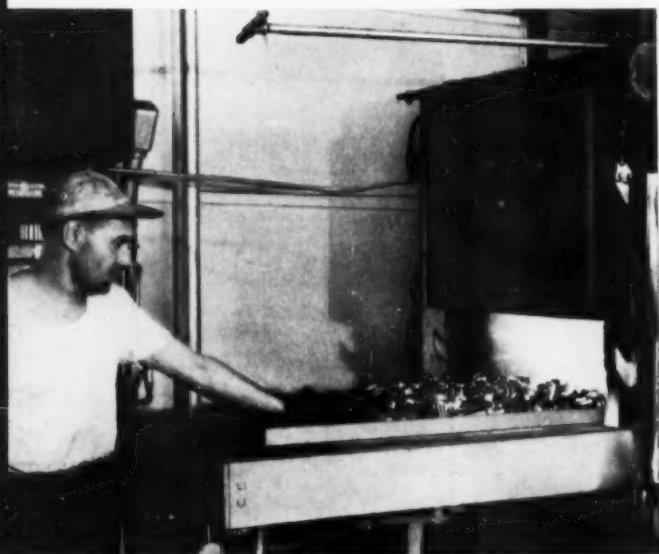
NAME _____
POSITION _____
ADDRESS _____
CITY _____ STATE _____

MODERN METAL PROCESSING



"**GREAT ONE-MAN HEAT TREATER**," is the way Greenman Steel describes this G-E box furnace with cooling chamber. Accurate control of the temperature is provided by the G-E control unit shown behind the furnace.

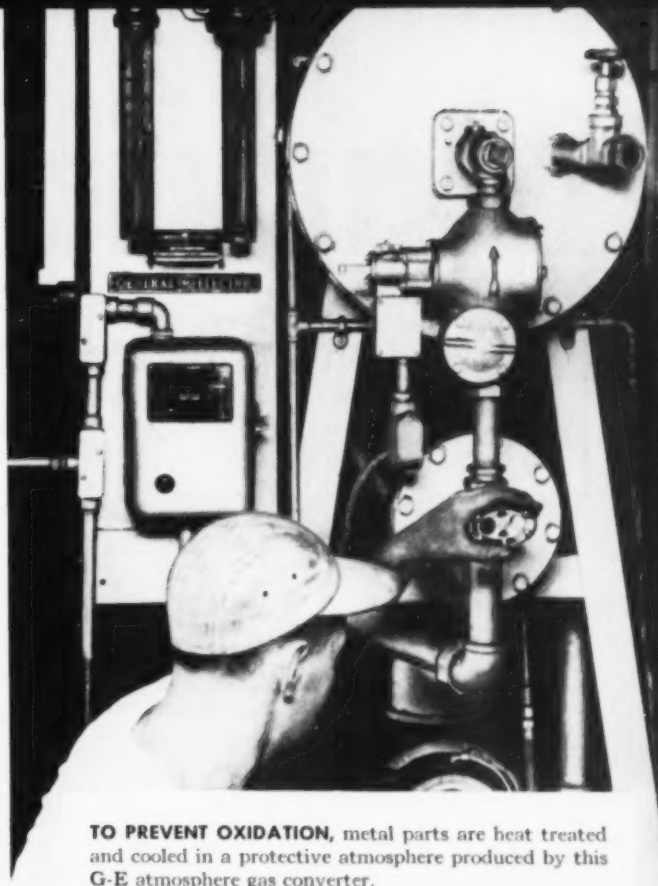
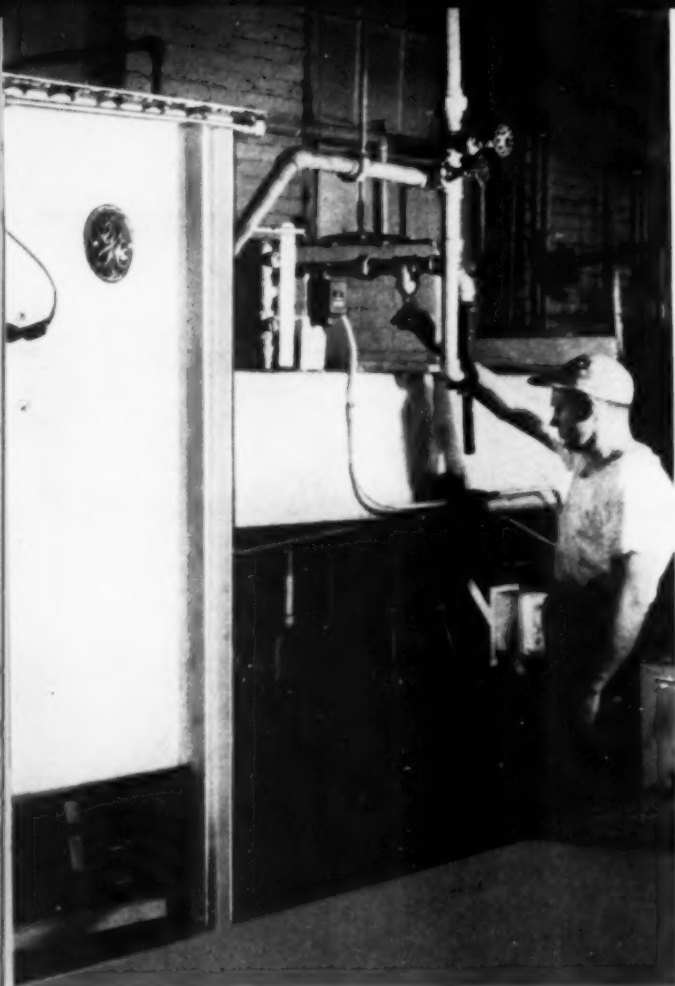
"Versatility of G-E Furnace Almost



MANY HEAT-TREATING JOBS can be done with this one G-E box furnace. Greenman Steel uses it for copper brazing, silver brazing, annealing, and hardening. Here, the furnace is employed to anneal drawn-steel cups.



HIGH-QUALITY WORK is achieved by moving the parts directly from the furnace to the atmosphere cooling chamber, thereby minimizing oxidation. Here, the parts emerge from the cooling chamber clean and bright.



TO PREVENT OXIDATION, metal parts are heat treated and cooled in a protective atmosphere produced by this G-E atmosphere gas converter.

Unlimited," Says Industrial Heat Treater

Operational savings of G-E furnace keep Greenman Steel competitive

Heat-treating jobbers who demand versatility in a furnace find that General Electric's box furnace with water-jacketed cooling chamber is ideal for general-purpose work.

Says Lloyd G. Field, General Manager of Greenman Steel Treating Corp., Worcester, Mass.:

"As a heat-treating jobber, we have to produce high-quality work at lower cost than equipment manufacturers can do it themselves. We must be ready to handle all sorts of heat-treating jobs, yet our investment in equipment must be kept to a minimum. We find that our G-E box furnace satisfies all these requirements. It enables us to stay competitive because it produces

superior work at low cost. It minimizes our equipment costs because its versatility is practically unlimited. We use it to copper braze, silver braze, anneal, and harden."

MANY SAVINGS, HIGH-QUALITY WORK

Mr. Field pointed out that operating costs are low because the insulating qualities of the furnace minimize heat loss. Automatic control of the heat assures him of high-quality work.

FOR APPLICATION HELP

Whether your operation demands a small-capacity, all-purpose furnace, or one that is engineered for a particular process and intended for high-production rates at the lowest possible cost, General Electric can satisfy your requirements. For application help from a G-E Heating Specialist, contact your G-E Apparatus Sales Office.

GENERAL  ELECTRIC

WRITE NOW FOR THESE MODERN METAL PROCESSING BULLETINS

• Furnace and Induction Brazing, GEA-5889

• Annealing Malleable Iron, GEA-5797

• Forging with Induction Heat, GEA-5983

• Heat-treating Aluminum, GEA-5912

Address: General Electric Co., Section 720-129, Schenectady 5, N. Y.

Marvibond

New vinyl-to-metal laminating process

Naugatuck's new and exclusive laminating process bonds Marvinol® vinyl sheeting to practically any kind of sheet metal—permanently! It gives metals all the famed corrosion and chemical resistance of vinyl plastic, one of the most inert of all known materials!

New Marvibond laminates end rusting—resist acids, alkalies, salt water, alcohol, household chemicals, corrosive industrial liquids and atmospheres . . .

• **give far greater corrosion and abrasion resistance than galvanized steel—much superior to varnish, phenolic, or alkyd finishes!**

• **withstand weather and humidity indefinitely!**

• **remain dimensionally stable up to 250°F!**

• **take more than 40 lbs. per inch in lap-off tests!**

• **will not chip, crack, craze, or flake off!**

• **will not support combustion!**

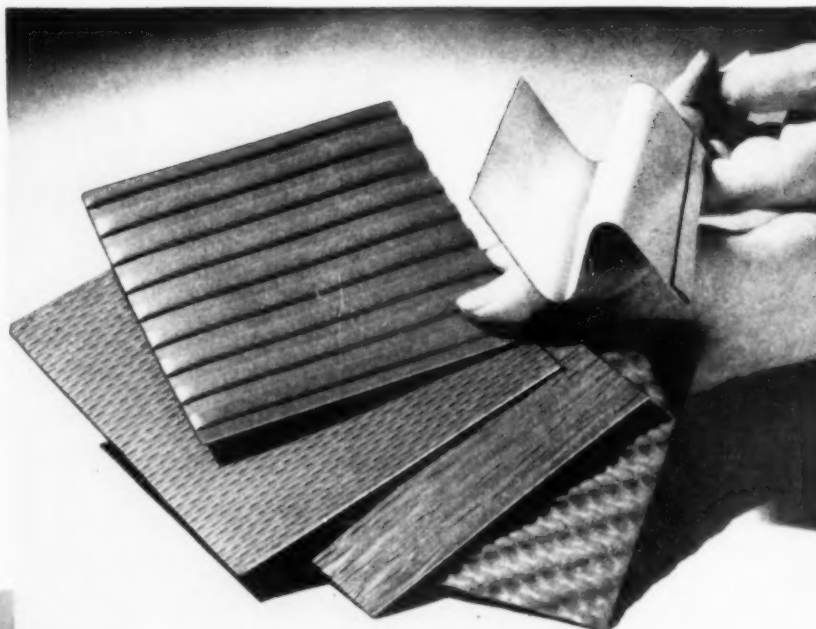
• **can be deep drawn, sheared, crimped, bent, embossed, drilled,**

and punched—with standard tools—without damage to coating or bond!

• **and cost less than stainless steel!**

Since Marvibond involves lamination rather than spraying, it gives all the excellent chemical, abrasion, and heat resistance of a polyvinyl chloride—protection not obtainable with a solution grade vinyl. *And it gives this superior protection at less cost.*

Illustrated are just a few of the many forms and products into which Marvibond has been fashioned—suggesting the tremendous scope of product possibilities this new process opens up.



gives metal the corrosion resistance of vinyl plastic!

Why not Marvibond for...



shower stalls?



small toys, carts, and accessories?



decorative panels and office partitions?



furnishings for home, office, or hospital?

Why not these and hundreds more . . .
chemical ducts and processing equipment
. . . machine housings . . . containers of all
sorts . . . electrical switch boxes and plates
. . . metal tiles . . . table tops . . . air washing
systems . . . countless products of practi-

cally every description.

Why not *your* product? If it's made of
sheet metal (or could be), Marvibond
offers both beauty and protection unex-
celled. Better write to the address below
for more details and sample test data.

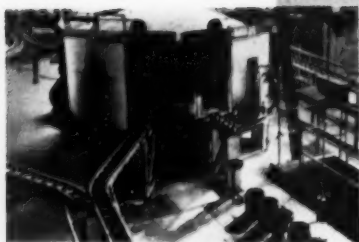
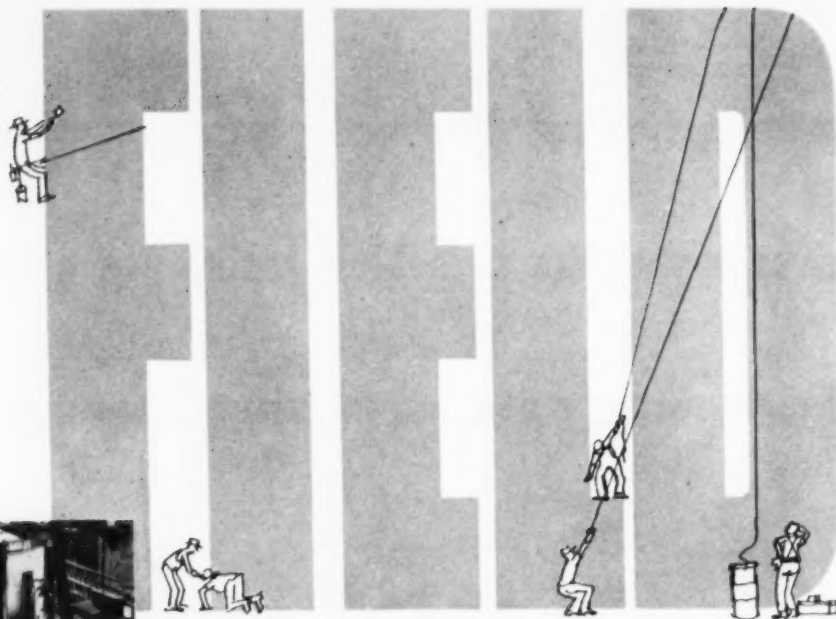


Naugatuck Chemical

Division of United States Rubber Company

36 ELM STREET, NAUGATUCK, CONNECTICUT

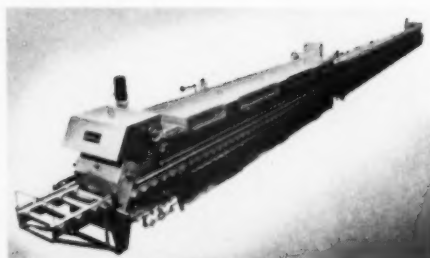
BRANCHES: Akron • Boston • Charlotte • Chicago • Los Angeles • Memphis
New York • Philadelphia • **IN CANADA: Naugatuck Chemicals, Elmira, Ontario**



AUTOMATIC ROTARY HEARTH FURNACE



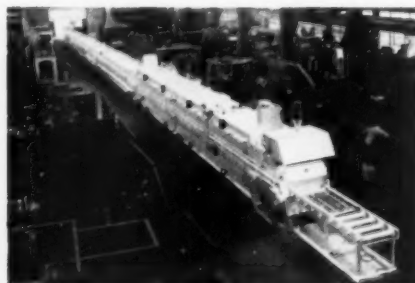
CONTINUOUS MESH BELT RECIRCULATING FURNACE



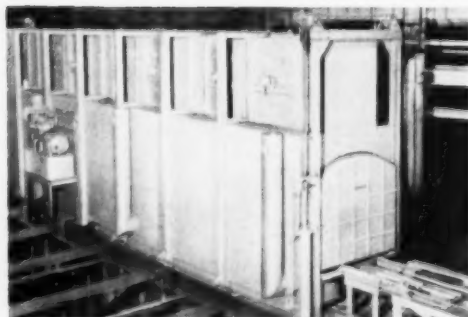
ROLLER HEARTH FURNACE



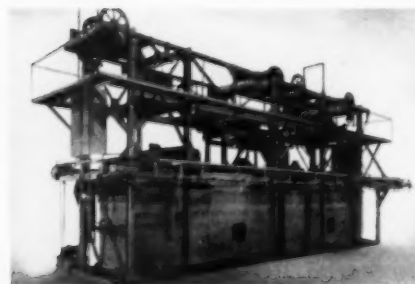
GAS-FIRED ATMOSPHERE TYPE FURNACE



CONTINUOUS ELECTRIC FURNACE



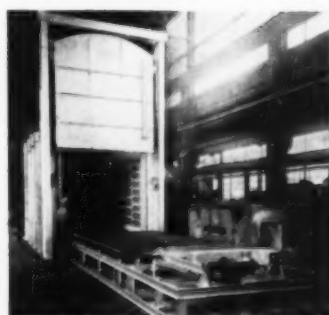
ALUMINUM BILLET HEATER



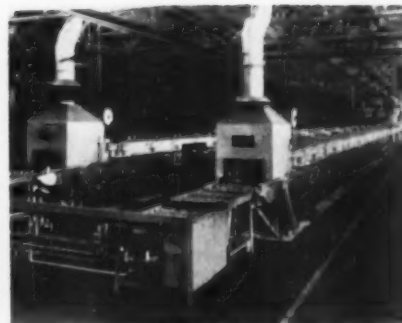
AUTOMATIC HEAT TREATING MACHINE



CONTINUOUS CONVEYOR FURNACE



AUTOMATIC ROLLER GRID FURNACE



CONTINUOUS BRAZING PRODUCTION LINES



CONTINUOUS VITREOUS ENAMELING LINE



CONTINUOUS CARBO-NITRIDING FURNACE

BIG ONES...by Lindberg

Maybe you haven't heard the news. Lindberg is now set up to field-erect any type of industrial heating or processing installation. Pictured on these pages are just a few of the large field-erected installations already put up by Lindberg. More are being built right now.

You get a complete package deal from Lindberg. Expert engineers consult with you and analyze your needs. Then they plan and design an installation to meet your specific requirements, whether you need a single furnace or a complete production line. And Lindberg will build it for you, right in your own plant.

To get on-the-spot service from an expert Lindberg engineer, just call your nearest Lindberg Field Office (you'll find the number in the classified section of your phone book, or in the Trade Directories).



LINDBERG INDUSTRIAL CORPORATION

Chicago Plant: 2321 West Hubbard Street, Chicago, Illinois

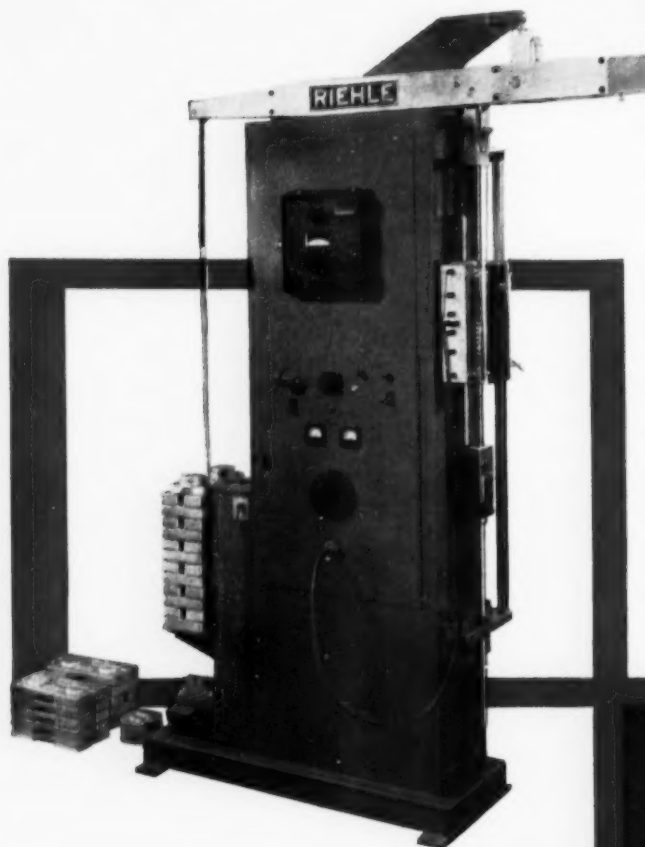
Los Angeles Plant: 11937 Regentview Avenue, at Downey, California

Field Offices in principal cities. Associate Companies: Lindberg Engineering Company, Chicago • EFCO-Lindberg, Ltd., Montreal • Lindberg Italiana, Milan, Italy

WHAT'S NEW IN CREEP TESTING?

AXIAL ALIGNMENT ASSURED

on this machine



THE RIEHLE CREEP TESTING MACHINE determines the stress required to rupture a specimen as well as the creep properties up to rupture. Capacity, 12,000 pounds.

Exclusive ball-seated loading clevis insures that specimen holders have freedom of motion, are self-aligning. So specimen is free from bending moments which would give erroneous results.

Hydraulic recoil absorber gently lowers weight when specimen fails.

Electrical equipment can be furnished as part of the Riehle "package," complete with wiring. Yet ample space has been allotted on panel and inside machine for alternate electrical equipment if desired. Integral control and electrical panel can be mounted on left or right side — favoring multiple installations in pairs, saving floor space.

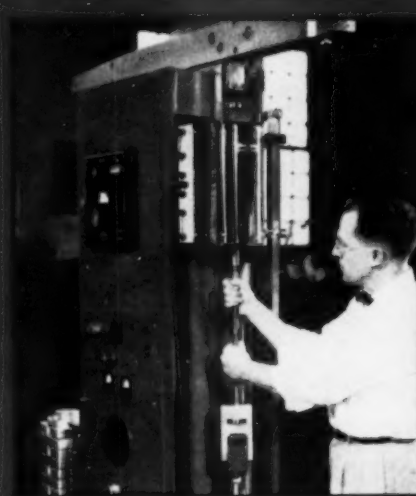
Automatic, electrically operated and controlled lever leveler can be furnished for maintaining lever in a horizontal or fixed position. When testing materials with relatively large amounts of strain occurring before failure, this feature is necessary.

Motorized elevator lifts weights, eliminates manual handling.

Furnace can be provided to meet your specifications . . . is readily accommodated by machine design. Counter-balanced furnace can easily be moved vertically, as well as in a sufficient lateral arc for centering about specimen.

Grip holders are furnished to your specifications . . . determined by temperature, type of specimen and size.

Riehle Creep Testers are available with all equipment described above — or, less any equipment not desired.



SEND FOR
FREE
BULLETIN
JUST MAIL
COUPON



MAIL COUPON TODAY

RIEHLE

TESTING MACHINES

Division of
American Machine and Metals, Inc.
EAST MOLINE, ILLINOIS

RIEHLE TESTING MACHINES
Division of American Machine and Metals, Inc.
Dept. MP-954, East Moline, Illinois

Yes, send me new free bulletin on the new Riehle Creep Testing Machine.

FIRM NAME _____
ADDRESS _____
CITY _____ ZONE _____ STATE _____
NAME AND TITLE _____

Semi-automatic Hardness Tester

A Rockwell motorized hardness tester, which is semi-automatic in operation, has been announced by the Wilson Mechanical Instrument Div. The device features a short test cycle to permit an increased number of Rockwell readings to be taken and recorded within a definite time period.



The motor's function in the test cycle is to remove the major load. The cycle of major load operation is less than 2 sec. Its application is controlled through a dash pot, which gives infinitely variable speed control. Power is supplied from a 110 volt, 60 cycle, single phase a-c line. The instrument features an illuminated dial gage, indenter light and the Set-O-Matic dial gage which returns the pointer to zero when minor load is applied.

For further information circle No. 950 on literature request card on p. 32-B.

Metal Cleaner

A new type of prephosphate metal cleaner to be used in mechanical spray processing equipment has been announced by the Detrex Corp. The cleaner is intended for use where a fine-grained phosphate crystal is required. It leaves the metal surface chemically clean and requires no surface seeding in the prephosphate coating stages. Subsequent phosphate coatings are extremely fine grained,

uniformly coated and thereby result in lower chemical consumption. Activating is accomplished without resorting to metallic activators.

For further information circle No. 951 on literature request card on p. 32-B.

Rust Removal

A new rust removing material that simultaneously strips paint, rust and primer from ferrous metal surfaces has been announced by Turco Products, Inc. The liquid alkaline material requires only two simple steps—a hot tank dip and an air-and-water or steam pressure rinse. According to

the manufacturer, it will remove slightly pitted rust in less than a minute, while heavy rust and multiple coatings of paint normally require an immersion of a few minutes. It contains no cyanide compounds, requires no electrolytic action and gives off no corrosive fumes.

For further information circle No. 952 on literature request card on p. 32-B.

Titanium Carbide Cutters

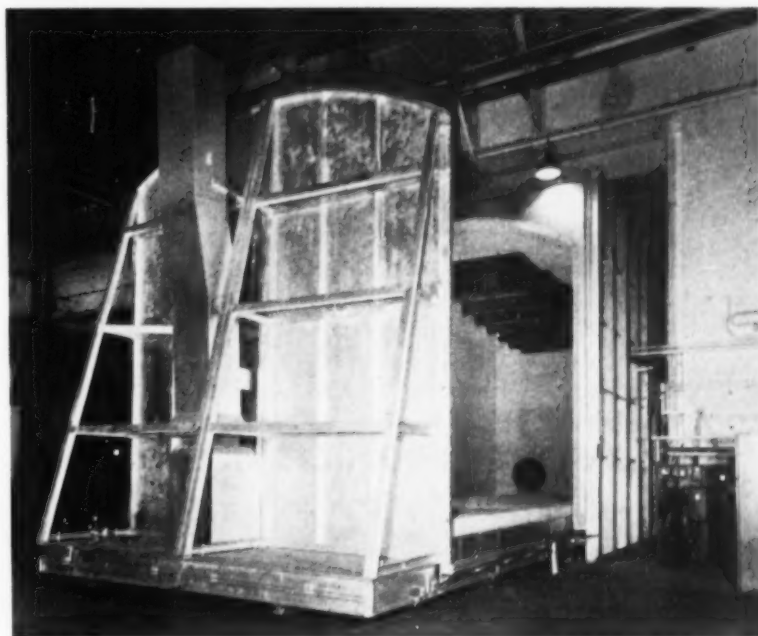
Firth Sterling, Inc., has announced the development of a new titanium carbide cutting material which contains no tungsten and no cobalt.

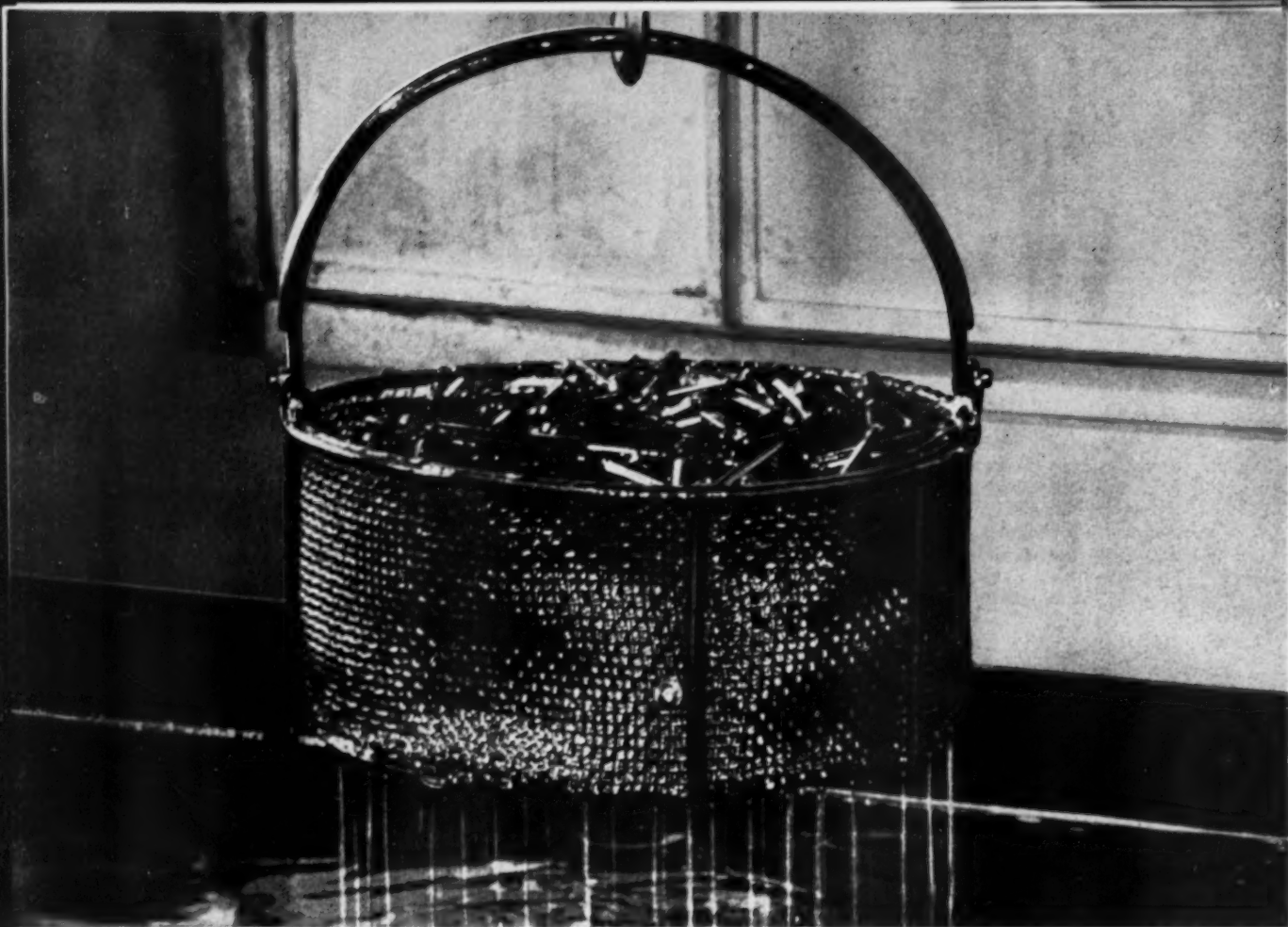
Large Single Chamber Heat Treating Furnace

A car-type heat treating furnace 30 ft. long, 18 ft. wide and 16 ft. high has been installed at the East Pittsburgh works of Westinghouse Electric Corp., and will be used for the stress relieving of large weldments. Parts weighing up to 100 tons may be treated at one time. Maximum operating temperature is 1600° F., but stress relieving will be performed at approximately 1175° F. The air pass-

ing through the combustion chamber is heated by the burning gas and enters the furnace from the rear through ducts suspended from the ceiling. This duct work distributes the heated air through various side openings as it travels toward the front. Air is drawn out of the furnace through two recirculating blowers having a total circulating rate of 120,000 cu. ft. per min.

For further information circle No. 953 on literature request card on p. 32-B.





You Get Minimum Drag-out with Sun Quenching Oil Light

When you reduce oil consumption by lowering drag-out, you cut a major cost in operating a quenching system. Sun Quenching Oil Light thins out when heated, drains off parts faster and more completely. And Sun Quenching Oil Light, because of its natural detergency, prevents the formation of sludge

deposits, aids in removing any deposits that have accumulated. And under normal operating conditions it need never be replaced. Sun's booklet "Sun Quenching Oils" tells about this low-cost oil. For a copy, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-9.

INDUSTRIAL PRODUCTS DEPARTMENT
SUN OIL COMPANY



PHILADELPHIA 3, PA. • SUN OIL COMPANY LTD., TORONTO & MONTREAL

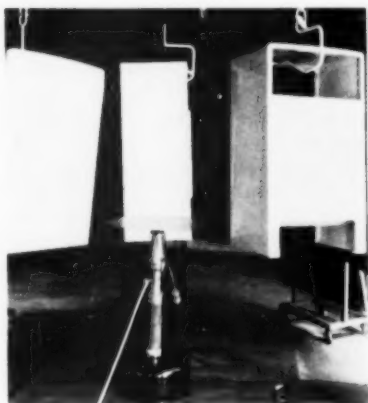
Made by the producers of famous Blue Sunoco Gasoline and Dynalube Motor Oils

Nickel is used as a binder instead of cobalt, and molybdenum carbide is used as an alloy carbide addition. The tungsten-free grades are characterized by high wear resistance and the cratering action of steel chips is greatly reduced. Tool life is excellent on steady finishing cuts, particularly when high speeds and fine feeds are employed in machining hard abrasive steels. They remain cooler than tungsten carbide grades when cutting steel without fluids.

For further information circle No. 954 on literature request card on p. 32-B.

Paint Atomizer

A reciprocating, disk-type atomizer, used in electrostatic spray painting, has been announced by Ransburg Electro-Coating Corp. With the up and down motion, the unit provides uniformity in painting small parts and big products such as refrigerator cabinets and doors. Parts are hung on



a conveyor which makes a circular loop in the electrostatic spray area. The atomizer is located in a pit in the floor in the center of the loop. Paint is pumped to the center of the disk which rotates to feed paint to the atomizing edge. High d-c. voltage is imposed on the disk, establishing an electrostatic field between the disk and the parts hanging on the grounded conveyor. This atomizes the paint into a fine spray and electrostatically attracts it to the surrounding parts.

For further information circle No. 955 on literature request card on p. 32-B.

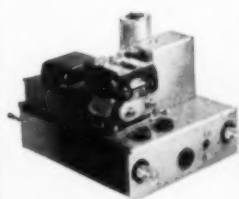
Plating Barrels

Cluster barrels, manufactured by the Udylyte Corp., are being used in the production plating of millions of small parts for office machines. They provide a rotary rack to hold small containers with the proper constant current conducted to each container. The mechanism consists of a shaft rotated by means of a large ring gear. For loading and unloading, the small

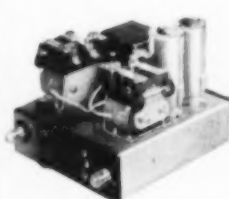


NEW Wheelco 400 Series Capacitrol

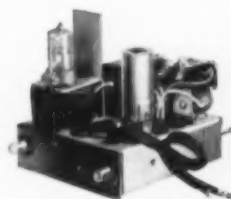
Plug in
the control
system
you
want!



Model 402 Chassis



Model 403 Chassis



Model 404 Chassis

Fully flexible in choice of control forms. Permits you to change systems to meet changes in heating requirements by plugging in proper chassis. No complicated adjustments. Model 402 Chassis provides "tru-line," or time-proportioning system for ultra-sensitive "anticipating" control. When input is "stepped," Model 403 Chassis gives you automatic multi-position control. For "on-off" firing, Model 404 is a heavy-duty (35 amp) chassis for two-position control requiring single-pole, single-throw switch action. *Electronic principle eliminates "drift."* Many "first features." Write for Bulletin F-6314.

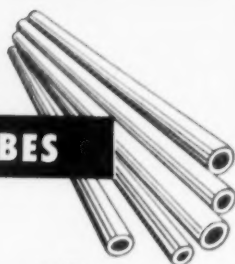
WHEELCO INSTRUMENTS DIVISION

BARBER-COLMAN COMPANY, DEPT. I, 1518 ROCK ST., ROCKFORD, ILLINOIS
BARBER-COLMAN OF CANADA, LTD., TORONTO, ONT., CANADA

Industrial Instruments • Automatic Controls • Air Distribution Products • Aircraft Controls • Small Motors
Overdoors and Operators • Molded Products • Metal Cutting Tools • Machine Tools • Textile Machinery

World's
largest
stocks
of
52100
STEEL TUBING AND BARS

TUBES



BARS



WIRE



FORGINGS



Write for the latest stock list
Contact our nearest office or write to
Peterson Steels, Inc., Springfield
Road, Union, New Jersey. Address
Dept. M.

PETERSON STEELS, Inc.
UNION, NEW JERSEY
BRIDGEVIEW, ILL. CHICAGO, ILL.

containers are snapped out of the clips which hold them and the lids lifted off. Each container has a built-in disk-type cathode contact making it a complete unit in itself. The cluster barrel can be used in the standard plating



barrel. It is particularly well adapted to plating products where the parts must be kept separate or for plating small delicate parts which cannot stand the tumbling action of standard bulk plating equipment.

For further information circle No. 956 on literature request card on p. 32-B.

Gamma-Ray Inspection

A new gamma ray machine, using radio-active isotopes to peer into dense materials, has been announced by Gamma Industries, Inc. This machine can penetrate steel plate up to 8 in. thick and is completely portable. In operation, radioactive rays pass



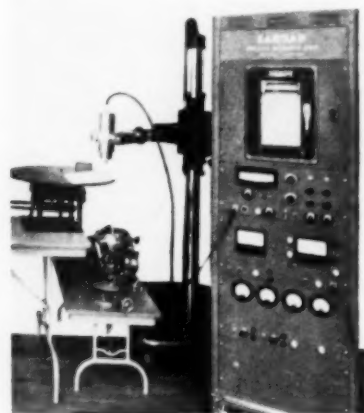
through a dense article and strike against a photographic film in holders behind the test object. The film, when developed, reveals a shadow picture of the specimen and its internal structure. The machine does not require huge amounts of lead insulation. It comes with five Curies of Cobalt-60.

For further information circle No. 957 on literature request card on p. 32-B.

Thickness Measurement

Nuclear Research Corp. announces a small angle radiation detection and presentation device for precise

control functions, such as measuring minute variations in thickness throughout pieces of sheet steel or determining flaws in welds. The unit has three major components—a radia-

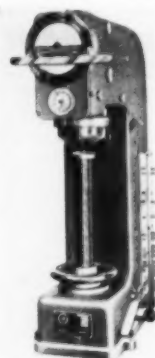


tion source, a counter which detects the beam after it has passed through the object being tested, and an electronic presentation system for noting and recording the variations in the beam. Further inspection applications are anticipated.

For further information circle No. 958 on literature request card on p. 32-B.

Hardness Testing

Reflex machines for Vickers, Knoop, Grodzinski, Brinell and Rockwell tests have been announced by Gries Industries, Inc. They feature test load capacities from 1 to 250 kg., push-button load selection and automatic projection. After the applied test load has been removed, the greatly magnified image (up to 140X) of the indentation produced is automatically projected on the ground glass screen. The ground glass can be replaced by a photographic plateholder. Test values are based upon the area of indentation rather than upon the depth of indentation.



For further information circle No. 959 on literature request card on p. 32-B.

Ultrasonic Gage

A 21-in. television tube is a feature of the new automatic ultrasonic thickness gage announced by Branson Instruments. The instrument measures thickness and detects laminar

An important message concerning a new —and unique— alloy steel

UNITED STATES STEEL is pleased to announce to all steel consumers a new steel which we feel sure will enable you to improve the performance, lengthen the life, and reduce the cost of industrial equipment. This new engineering material is USS Carilloy T-1 steel, which recently underwent some very severe testing in Birmingham, Alabama.

The development of T-1 steel began back in 1947, when our research people took a good look at a problem that had plagued alloy plate steel users for years. That problem was the multiplicity of compositions required to do everyday jobs. There was no one composition available that could serve a wide variety of applications—so our research people set out to develop such a steel. The steel we wanted had to possess

many unusual attributes such as very high strength, unusual toughness, good weldability and excellent resistance to impact abrasion at temperatures from minus 150°F. up to as high as 900°F.

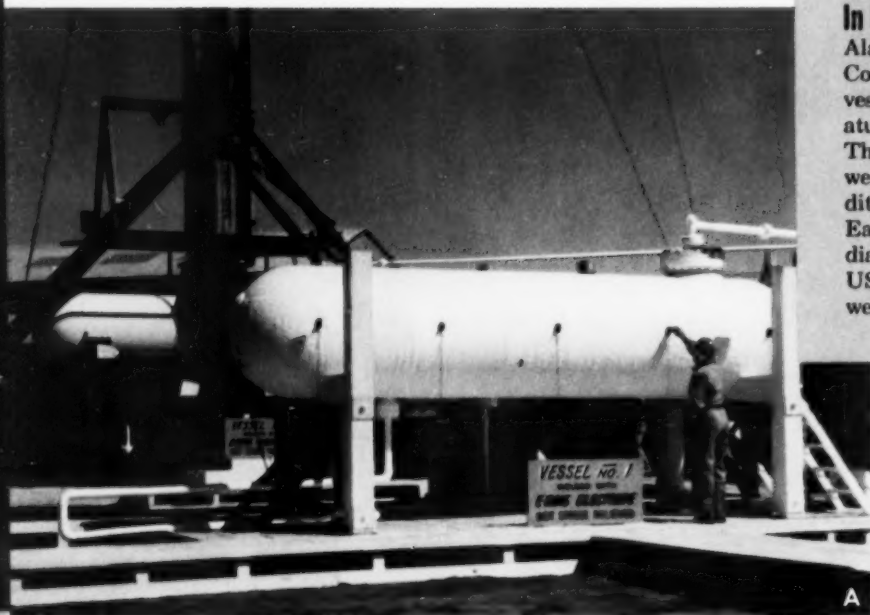
Today such a steel is a reality. It is USS Carilloy T-1 steel, which has been tested thoroughly, both in the laboratory and in actual service applications. To prove further the capabilities of this new Carilloy steel, Chicago Bridge & Iron Company and United States Steel this summer carried out a joint testing program on commercial pressure vessels built from T-1 steel. The results of these tests and their significance to all steel users are described on the next three pages. We feel sure that you will find the story well worth reading.



UNITED STATES STEEL

Remarkable new engineering material

PROVES SUPER-TOUGH



In May and June, 1954, at the Birmingham, Alabama, plant of Chicago Bridge & Iron Company, eight welded cylindrical pressure vessels were refrigerated to subzero temperatures and deliberately tested to destruction. The vessels were all standard designs that were built under normal production-line conditions by Chicago Bridge & Iron Company. Each vessel was twenty feet long, four feet in diameter, and made of half-inch plates of USS Carilloy T-1 steel. Four of the vessels were welded without stress relieving, using

In pressure test at 38°F. below zero T-1 steel withstands stresses 3 times its design strength

This vessel, not stress relieved, was refrigerated to -45°F. Then, with a quarter inch of white frost clinging to its sides, a high pressure pump slowly chugged the pressure in the vessel up to 938 psi. At that point, the steel itself was stressed to 45,000 psi., which is one half the yield strength of T-1 steel.

The hydraulic pressure was forced still higher, to 1875 psi. At this pressure, the stress in the steel had reached 90,000 psi.—the full *nominal* yield strength. Still, every inch of the metal was sound and all welds were intact.

Now the test really came. The pump labored on, and the pressure climbed to 2,000 psi. . . . to 2500 . . .

to 2850 psi. . . . then . . .

BOOM! A jet of yellow brine burst out of the vessel and shot 200 feet through the air. The vessel finally failed at a pressure of 2850 psi. and a minimum stress of 136,000 psi. on the plates. This stress is well over three times the design strength of 45,000 psi.

The temperature of the steel at the time of failure was a frigid 38 below, yet the metal showed no sign of brittle failure. Super-tough USS Carilloy T-1 did what no ordinary steel could do at such a low temperature—it stayed *tough and ductile*; in fact it actually stopped the tear from propagating any further through the vessel.



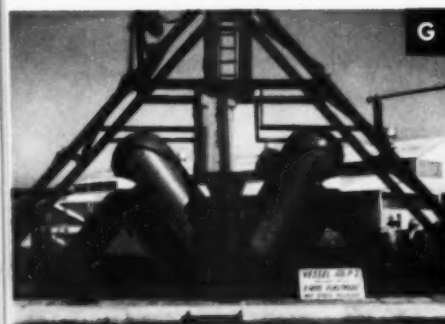
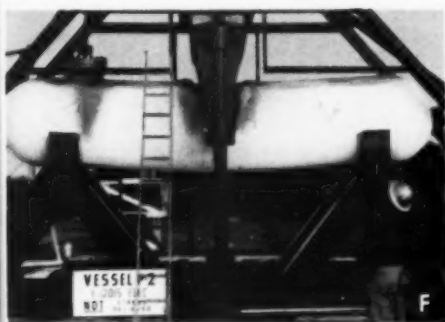
UNITED STATES STEEL

USS CARILLOY **T₁** STEEL

DOWN TO 38°F. BELOW ZERO

E 12015 low hydrogen coated electrodes. The other four were welded with E 9015 electrodes and were stress relieved after welding. Two vessels of each type were given two tests: a pressure burst test for strength and ductility, and an impact punishment test for toughness and resistance to the most severe impact conditions that could be devised.

Results of these tests, described below, prove conclusively the exceptional strength and toughness of USS Carilloy T-1 steel, even at temperatures far below freezing.



Frozen steel vessel made of Carilloy T-1 survives blow from 13-ton ingot dropped 73 ft.

A steel ingot weighing 26,700 lbs. has just plummeted 52 feet and crunched on top of this test vessel (Fig. E). The ingot was traveling 39 miles per hour when it hit. It struck with an impact energy of about 1,400,000 ft. lbs., bounced fifteen feet, and crushed down again on top of the vessel.

This vessel was welded without stress relieving. It was refrigerated to 33 F. below zero. It was pressurized to 1,875 psi. equal to a stress on the plates of 90,000 psi.—the steel's *nominal* yield strength. Yet, it did not fail. The ingot left only a $\frac{3}{16}$ inch dent in the top, with a slight bulge on either side of the dent.

The test was repeated (Fig. F). This time the ingot was raised 73 feet, then dropped. It pounded down again on the very same spot on top of the vessel. Traveling at 46.7 miles per hour, it hit with an impact blow

of 1,960,000 ft. lbs. The dent merely deepened—the steel and all welds were still intact.

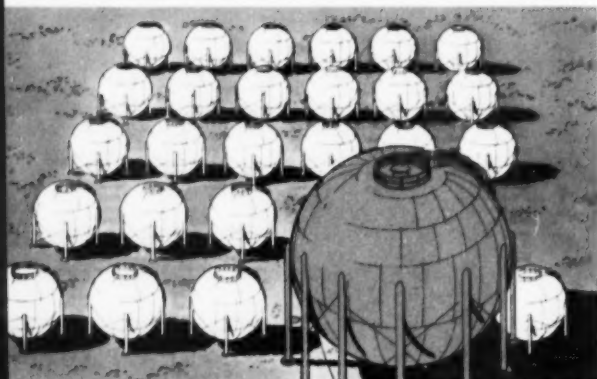
Again the test was repeated (Fig. G). Now dropped from 101 feet, the 13-ton ingot ploughed into the top of the vessel at a speed of 55 miles per hour, hit with an impact of 2,750,000 ft. lbs. This time the vessel failed. But it didn't shatter. It didn't crack. It tore open like a tough piece of hickory. In other words, it failed without any signs of brittleness, even though the temperature of the steel was now minus 22° F.

In addition to this tremendous resistance to impact abuse, combined with remarkable sub-zero toughness, Carilloy T-1 steel also gives you excellent resistance to impact abrasion ... good high temperature strength ... and exceptional weldability.

Turn the page to see how you can use this remarkable new steel to cut costs and improve performance in a great variety of products.

Here's where you can reduce costs

with USS Carilloy **T₁** steel



IN PRESSURE VESSELS. To illustrate how the high yield strength of Carilloy T-1 steel can pay off here, consider this fact: To store 25,000 bbls. of propane at 210 psi would ordinarily require 25 mild carbon steel vessels. In contrast, only one large vessel made of T-1 steel of the same thickness would do the job. This single T-1 vessel would require 1/3 less shell material, 14% less foundation concrete, 70% less welding and 84% less space.



IN STEEL MILLS. In skip cars, T-1 steel in the bottoms, sides, and bail plates lasts three times longer than steels now in use. T-1 steel also gives exceptionally long service in coke bins and chutes, in ore transfer cars, in draft lines, in conveyor chains, and crane hooks. In clamshell buckets, T-1 steel has taken heavy abuse at temperatures from 500° to 600° F. and lasted nine times as long as the wear resisting steel previously used.

IN EXCAVATING EQUIPMENT. The dipper stick, bail, and bucket of this big electric shovel are fabricated of T-1 steel plate. The superior strength and durability of Carilloy T-1 made it possible to increase the capacity of the bucket from 35 to 45 cu. yds.



• The pressure vessel tests described on the previous pages indicate only one of the many possible uses of Carilloy T-1 steel. For this new engineering material has advantages not only in pressure vessels and storage tanks, but it also has proved itself in power shovels, bulldozers, mining machines, mine cars, steel mill ladles, blast furnace draft lines, lift trucks—in high speed rotating machinery, in stamping or forging presses. It is being considered for use in tension members of cantilever bridges and other similar applications where tension members are involved.

With the 90,000 psi. minimum yield strength to work with, combined with extraordinary sub-zero toughness, good high temperature strength to 900° F., and excellent resistance to impact abuse, impact abrasion, and atmospheric corrosion, you can use T-1 steel to reduce the size and weight of heavily stressed parts. This cuts your shipping and handling costs, as well as the cost of material, and the cost of foundations and supports where they are needed. Carilloy T-1 steel lengthens the life of your equipment, cuts repair bills and outage time. And remember, wherever you use T-1, you can weld or flame cut it either in the shop or in the field without expensive heat treating equipment. This cuts costs still further.

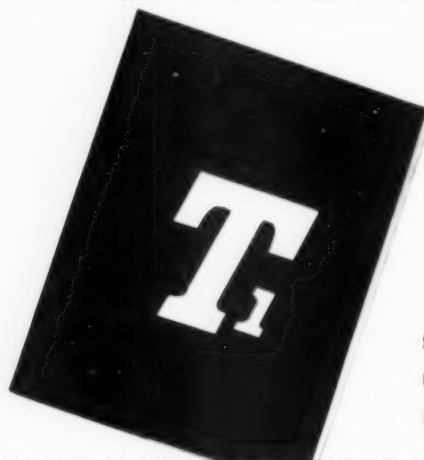
UNITED STATES STEEL CORPORATION, PITTSBURGH

COLUMBIA GENEVA STEEL DIVISION, SAN FRANCISCO

TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.

UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS

UNITED STATES STEEL EXPORT COMPANY, NEW YORK



**SEND COUPON
FOR COMPLETE
INFORMATION.**

United States Steel, Room 4481
525 William Penn Place
Pittsburgh 30, Pa.

- ☐ Please send me your booklet "United States Steel presents T-1" which contains the full story of T-1 steel.
- ☐ Have your representative get in touch with me.

Name

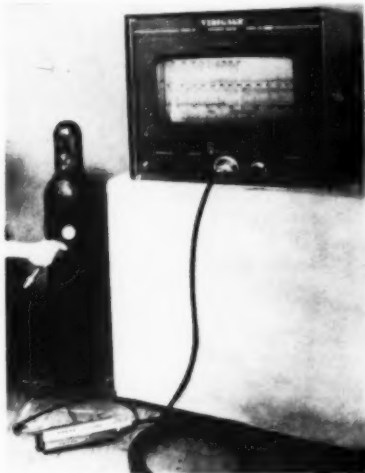
Address

City

State

UNITED STATES STEEL

flaws, including lack of bond non-destructively from one side of the work. A sweep-width adjustment permits wide choice of thickness scales, making it possible to read directly thicknesses from 0.012 to 2.5 in. with accuracies as high as 0.1%. Beyond 2.5 in., thicknesses up to 10 in. can



be calculated. The vacuum tube oscillator uses a specially designed variable inductor for the frequency sweep to vary the inductance instead of the capacitance. This has permitted replacement of a heavy, motor-driven capacitor with a small, self-contained, plug-in assembly without moving parts.

For further information circle No. 960 on literature request card on p. 32-B.

Measuring Magnetic Properties

General Electric Co. has announced a new device for measurement and calculation of the magnetic characteristics of metal. The d-c. recording hysteresisgraph traces the magnetic "signature" of a metal directly onto a scaled chart in a matter of minutes. It is able to compile and calculate these data with the use of two flux-

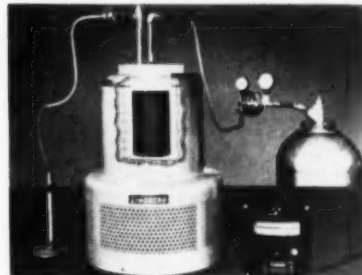


meters which integrate the flux voltage continuously. There are nine different sensitivities in the hysteresisgraph ranging from a full scale reading of 0 to 2000 interlinkages to 0 to 1,000,000 interlinkages. These permit the accurate measurement of materials ranging from ferrites to high permeability nickel iron alloys. Its repetitive accuracy is better than 0.5%. It can draw the hysteresis loops of tiny ring specimens or of solid bar material.

For further information circle No. 961 on literature request card on p. 32-B.

Laboratory Dissociator

Lindberg Engineering Co. has announced the first commercial laboratory-size dissociated ammonia generator. A stainless steel catalyst chamber with a vertical inlet and outlet tube was designed to fit into the laboratory pot crucible furnace.



The tubes are welded to the cover plate of the furnace to form a complete gas tight unit. Pure nickel shot surround the tubes within the catalyst chamber. The furnace is brought to an operating temperature of 1900 °F. and held there. The ammonia cylinder is then cracked open, the raw ammonia gas flowed through and cracked in the catalyst chamber. A needle valve controls the flow of dissociated gas to the work. This flow is checked by a flow-meter and the gas then directed to the point of use.

For further information circle No. 962 on literature request card on p. 32-B.

Dry Abrasive Cutting Machine

The Campbell Machine Div. has announced a new dry abrasive cutting machine. This 62-in. high machine is available in stationary and portable types and has ample capacity for cutting solid steel bars up to 4 by 4 in., angles and channels up to 8 in., and tubes and pipes up to 4 in. outside diameter. Hand-operated self-centering workholders clamp the work on both sides of the cut or a foot-actuated treadle can be furnished.

**ELIMINATE
COSTLY
SMALL PARTS
MACHINING
WITH...**



PRECISION INVESTMENT CASTING

Small, intricate parts that formerly required costly machining or assembly time can now be produced economically, accurately, and to a high finish, by Precision Investment Casting. Parts with undercuts, cores, and holes, are a "natural" for this precision process.

This modern casting technique offers increased production, lower manufacturing costs, and a greater freedom in the development of new parts.

SEND FOR THE INVESTMENT CASTING STORY

Write for free 12-page booklet — "MODERN PRECISION INVESTMENT CASTING" — the most complete source of facts and data available today.



Can You Use The "Grain That Stops Lightning"?

CRYSTOLON* silicon carbide (SiC), electrochemically produced from silica sand and coke, is produced by Norton in many forms. One of these forms, E-179 CRYSTOLON grain, is known as "lightning arrester grain" because of its carefully controlled electrical properties — obtained by specially controlled furnacing techniques, which lower its surge impedance.

In Commercial Lightning Arrestors

E-179 CRYSTOLON grain has the particularly useful property of acting as an insulator at low voltages and as a conductor at high voltages. This "valving" action, analogous to pressure-controlled valves in a fluid system, is provided in the arrester circuit by a spark gap in series with an E-179 grain unit, loose or molded into blocks. The number of series used varies according to the arrester's voltage rating.

The non-linear behavior of E-179 CRYSTOLON grain may be expressed in terms of voltage and current by the equation:

$$V = AI^n$$

where A is a constant for a given sample, and n, the exponent, is approximately 0.1 for E-179. For a material where the exponent $n = 1$, the equation becomes Ohm's Law: $V = IR$. The value of A is controlled by the method of manufacture. The exponent is constant over a wide range of surge impedance.

Ceramic Non-Ohmic Resistors

In the form of block, disc or rod are composed of a fired mixture consisting principally of a ceramic bond and E-179 CRYSTOLON grain. The nature of this crystalline silicon carbide determines the finished characteristics of the resistors. Both the nominal grain size and actual distribution of grain size around the nominal are factors which must be controlled.

E-179 CRYSTOLON grain is available in grit sizes from 60 to 240, inclusive, manufactured to customers' specifications, with impedance values measured for every lot of grain in each grain size.

Besides the applications mentioned, other uses for this special CRYSTOLON

grain are: spark plug resistors, railroad blocks and discs, voltage control devices and varistors for telephones.

Regular CRYSTOLON Grains

share the common characteristics of great mechanical strength and resistance to heat shock. And in refractory applications the high thermal conductivity of CRYSTOLON material — 8 to 10 times that of ordinary fireclay — is a distinct advantage.

CRYSTOLON silicon carbide dissociates without melting at the extreme temperature of 4170°F. It is an acid refractory and at elevated temperatures resists all slags except those high in alkalis. Other characteristics include: maximum operating temperature — 2800°F; specific gravity — 3.20; bulk density — 98 lbs. per cu. ft.; hardness (Knoop) — 2500; crystal structure — hexagonal system, hemahedral class. A typical chemical analysis shows:

SiC	98.13%
Free SiO ₂	.50
Fe	.25
Al	.25
Free C	.20
CaO	.15
Si	.50
MgO	.02

Regular CRYSTOLON material is used for: metallurgical additions; as a source of silicon for silicon tetrachloride base silicones; for electrical heating elements; and for refractory cements and shapes for industrial furnaces which utilize its high thermal conductivity, high hot strength and good thermal shock resistance.

Other Norton Basic Materials

include ALUNDUM* fused alumina, MAGNORITE* fused magnesium oxide, NORBIDE* boron carbide, Fused Stabilized Zirconia and many others, including a number still undergoing research and development.

These high-melting materials which have varied applications in many fields, are also the basic ingredients of the famous Norton Refractory R's — refractories engineered and prescribed for the widest range of uses.

For Your Own Applications or Developments

Norton Company not only supplies these materials in their crude form, but has extensive facilities for processing and fabricating — and is ready to work with you in engineering materials to your particular requirements. A new booklet "Norton Refractory Grain — Electrochemically Refined" contains detailed information on these interesting materials. NORTON COMPANY, 328 New Bond Street, Worcester 6, Massachusetts.



E-179 CRYSTOLON grain, which insulates at low voltages, becomes a conductor at high voltages, thus providing "safety-valve" action in this lightning arrester. Processed by Norton to develop unique electrical properties, this high-purity silicon carbide grain is finding an ever-widening field of usefulness.

NORTON
REFRATORIES

Engineered... **R**... Prescribed

*Making better products...
to make other products better*

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

Where to use **Luster-on**[®] Chromate Type Conversion Coatings

Luster-on products meet such Government Specifications as:

OS — 1374
72 — 53
AN — P — 32a
QQ — P — 416
QQ — Z — 325

Luster-on K, 15, 25, 25AB for

Bright, clear, decorative finishes or iridescent and color coatings to meet the toughest corrosion resistance requirements on zinc plate and zinc-base die castings.

Luster-on CD Special for

Brilliant finish and outstanding corrosion protection on cadmium.

Luster-on Khaki Drab and Olive Drab for

Maximum protection with least possible metal removal on zinc plate and zinc-base die castings.

Protective Dip #60

Golden protective finish for magnesium.

Luster-on Cobra

Produces bright lustrous surface on copper and brass. Offers excellent corrosion and tarnishing protection. Eliminates buffing operations. No toxic fumes in this process.

Luster-on finishes, used by many of the country's largest metal finishers, have established themselves over ten years as a dependable, low-cost treatment for thousands of metal items. Data sheets and technical service are available without cost or obligation.

Send Sample Parts for Free Processing to your Specifications

L-12

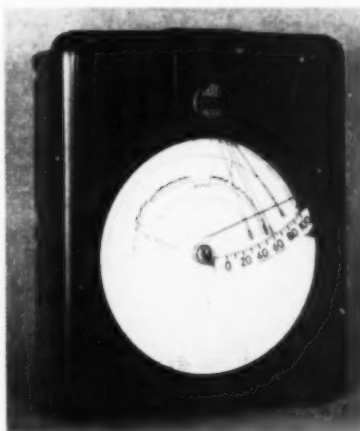


The cutting time is approximately 3 sec. per sq. in. of material cut. The cutting wheel is totally enclosed except for work clearance openings on the sides of the guard.

For further information circle No. 963 on literature request card on p. 32-B.

Recorder

The Bailey Meter Co. has announced a receiver recorder for pneumatic and electric transmission systems in power and process plants. Plug-in, pre-calibrated receivers provide continuous, independent records of one to



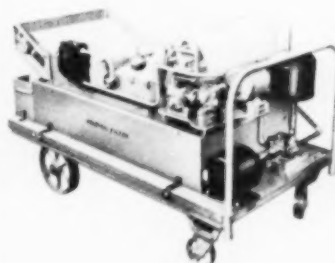
four pneumatic and electric transmissions in any combination. Receiver units may be added or interchanged, permitting easy field adaptation to new or revised metering and control applications.

For further information circle No. 964 on literature request card on p. 32-B.

Portable Filtration Unit

A new portable filtration unit incorporating the disposable belt-type filter has been announced by the Industrial Filtration Co. Units are mounted on casters for transportation for periodic filtration of various liquids and oils which do not require continuous filtration. They make use of a variety of filter media for numerous filtration requirements.

For further information circle No. 965 on literature request card on p. 32-B.



What do you know about the **Moly-sulfide** A LITTLE DOES A LOT LUBRICANT?

You may have heard about a highly successful solid-film lubricant which is giving remarkable results in the shop and in the field.

In one 40-page booklet we have collected 154 detailed case-histories describing how difficult lubrication problems have been overcome by molybdenum sulfide. If you wish to be up to date about this solid-film lubricant, fill in the coupon below, attach it to your letterhead and send it off today.

THE LUBRICANT OF MANY USES

Moly-sulfide
A LITTLE DOES A LOT

Climax Molybdenum Company
500 Fifth Avenue
New York City 36 - N. Y.



SEND FOR THIS FREE
BOOKLET TODAY

Name _____
Position _____
Company _____
Address _____
MP9 MS-3



A New Concept In Quenching Oil

the **SINCLAIR QUENCHOL** 500 SERIES

Sinclair introduces a premium product *which assures performance results heretofore unobtainable in conventional quenching operations*. Research has shown how quenching oils can be fortified with high cooling power characteristics. The high sludge resistance and low acid formation properties of QUENCHOL[®] is further evidence of its superiority — due in part to the high quality, high viscosity index Phetone Processed base oil selected for its formulation.

Important Advantages of Quenchol

- Reduces rejects
- Improves quality control
- Increases quality production at reduced cost
- Provides greater flexibility in quenching various grade steels
- Provides minimum drag-off and oil loss due to vaporization
- Offers an opportunity to upgrade lower cost steels for more critical usage

If you would like to see QUENCHOL in action, consult your local Sinclair representative for further details and a demonstration, or write for a free copy of "Quenching Oil" — a 12-page book on the new Sinclair QUENCHOL 500 Series. Gives results on hot wire quench test and in plant operation. *No obligation*. Sinclair Refining Company, 600 Fifth Avenue, New York 20, N. Y.

SINCLAIR

WHAT'S NEW IN MANUFACTURERS' LITERATURE

987. Abrasive Wheels

Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

988. Alloy Castings

22-page bulletin 2041 on heat and corrosion resistant castings. *Blaw-Knox*

989. Alloy Steel

16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

990. Alloy Steel

Leaflet on "Jalloy, Grade 3" special alloy steel for heavy duty use. Heat treatment, applications, properties and composition. *Jones & Laughlin Steel*

991. Alloy Steel

Data book on the selection of the proper alloy steel grades for each manufacturer's needs. *Wheelock, Lovejoy*

992. Aluminum Alloy

8-page bulletin on Ternalloys, high-strength aluminum base alloys, gives composition, properties, castability, machinability, welding and brazing. *Aper Smelting Co.*

993. Aluminum Cleaning

48-page booklet gives practical tips on materials and methods of cleaning aluminum and magnesium. *Oakite*

994. Aluminum Die Castings

Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

995. Aluminum Forgings

Booklet describes facilities for aluminum extrusion and forging. *Bridgeport Brass*

996. Ammonia Dissociators

Bulletin on dissociating process gives advantages of ammonia as controlled atmosphere. *Sargeant & Wilbur*

997. Atmosphere Furnace

Bulletin on controlled atmosphere furnace. *Industrial Heating Equipment*

998. Atmosphere Furnace

Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

999. Atmospheres

8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

1000. Atmospheres

Bulletin 439 on exothermic atmosphere generators for converting natural gas, manufactured gas, propane or butane. *W. S. Rockwell*

1001. Barrel Finishing

New brochure on tumbling barrel and the deburring and burnishing of stampings, castings and other metal parts. *Abbott Ball Co.*

1002. Basic Materials

24-page booklet on Alundum, Crystolon, Magnorite, Norbide, zirconia, carbides, borides and other basic materials. Products made from them are listed. *Norton*

1003. Bending and Cutting

Folder describes hand and air-operated bender-cutter and its applications. *J. A. Richards*

1004. Beryllium Additive

4-page leaflet on aluminum and magnesium-base master alloys for making beryllium additions to light metals. *Beryllium Corp.*

1005. Beryllium Copper

New 4-page bulletin on beryllium copper strip. Sizes of strip, engineering properties, tempers. *American Silver Co.*

1006. Black Oxide Coatings

8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

1007. Black Oxide Finish

Folder on penetrating black finish for ferrous metal. *Puritan Mfg.*

1008. Blackening Stainless

Bulletin on process for blackening stainless steels, cast and malleable irons. *Mitchell-Bradford*

1009. Boron Additive

6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

1010. Brass

Bulletin B-39 on Formbrite drawing and forming brass. *American Brass*

1011. Brass

80-page book on properties and uses of brass forgings, sand castings, rods and machinings. *Mueller Brass*

1012. Braze Tubing

12-page data book on braze tubing made from copper coated steel. *Bundy*

1013. Brazing

Discussion of brazing of SAE-1010 bicycle forks in a mechanized salt bath furnace. *Ajax Electric*

1014. Brazing Aluminum

12-page bulletin, ADR 45, on how to torch braze aluminum and strength of joints so brazed. *Air Reduction Sales*

1015. Brazing Titanium

Data sheet on use of a new flux for brazing titanium. *Handy & Harman*

1016. Brinell Machine

Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*

1017. Burners

Bulletin on piloted entrainment burners gives information on construction and specifications. *Eclipse Fuel Engineering*

1018. Burners

16-page bulletin on selection of gas burners. *Western Products*

1019. Cam

Bulletin on three dimensional cam which has 720 stations on just 1 sq. in. of surface. Engineering and production data. *Parker Stamp Works*

1020. Carbon and Graphite

20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

1021. Carbonitriding

28-page booklet on nature of process, furnaces, atmospheres, parts carbonitrided and properties. *Armour Ammonia*

1022. Carbonitriding

Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

1023. Case Hardening

Bulletin 159 describes standard rated batch furnaces for case hardening. *Surface Combustion*

1024. Centrifugal Castings

Booklet on spun centrifugal castings of bronze for liners, rings, rolls, sleeves, bushings. *American Non-Gran Bronze*

1025. Ceramic Coatings

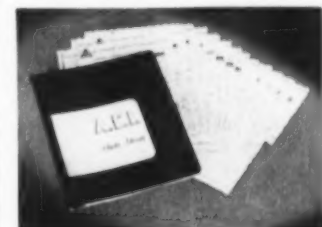
8-page bulletin on ceramic coatings for high temperatures. Their advantages on steel and aluminum. *California Metal Enameling Co.*

1026. Chromate Coatings

Folder gives characteristics and uses of chromate conversion coatings on non-ferrous metals. *Allied Research*

986 Corrosion Resistant Casting Alloys

Thirteen data sheets on corrosion resistant castings present information for the user on the commercially available alloys. Each sheet gives a description of the alloy dealt with, its heat treatment, applications, summary of properties, design and



fabrication considerations and designations for the alloy. The compilation has been made by the Specifications and Designations Committee of the Alloy Casting Institute. Data have been collected from many sources and in cooperation with such groups as the A.S.T.M. and the S.A.E. *Alloy Casting Institute.*

1027. Chromium Cast Iron

48-page book on effects of chromium on properties of cast iron. Data on production and uses. *Electro Metallurgical*

1028. Clad Metals

24-page booklet on principles of bonding, characteristics of clad metals, methods of cladding and applications. *Superior Steel*

1029. Clad Wire

Booklet on properties of nickel-clad copper wire for conductivity use at high temperature. *Sylvania Electric*

1030. Cleaner

Folder gives data on metal cleaners for



**New Jobs for One of the World's
Most Useful Metals:
STRAITS TIN from MALAYA**

Concentrating tin ore in Selangor, Malaya. Malayan economy depends heavily on tin exports. Thus a continuing and stable market for tin is as vital to Malaya as a continuing and stable supply is to the United States.

New Tin Alloys---New Techniques Make Soldering Faster, More Efficient

They've been using tin-rich solders for almost 2000 years — and haven't found a real substitute yet! Nothing else is as cheap or easy to use in making corrosion-resistant, impermeable, electrically conductive joints at relatively low temperatures.

Making Solder Still More Efficient

Now, new alloys and new soldering techniques are making tin solders still more useful on production lines.

A solder of tin-indium, for example, is now used for sealing glass to metal or glass to glass—will adhere to mica, quartz, thermosetting plastics, and some glazed ceramics, as well.

For joining aluminum, cerium added to a tin-rich, tin-zinc solder gives both improved salt spray resistance and better wettability.

New techniques for applying solder include ultrasonic methods of soldering and tinning aluminum, and the new mechanized dip soldering process that is saving industry thousands of man-hours.

Tin is, of course, the key ingredient in solder. Over one-third of the world's tin is mined and smelted in Malaya. Known as Straits Tin, this metal is more than 99.87% pure and is world-famous for its absolute reliability of grade.

A New Look at Straits Tin

Today, not only new solders but new tin alloys, new tin-alloy coatings and platings, and new uses for tin chemicals have been discovered that make Straits Tin more valuable than ever to American industry. And continuing research will find still more ways in which tin can serve you in the near future.

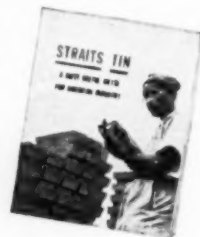
Whatever your product or process may be, now is the time to reappraise carefully the unique combination of properties of Straits Tin. For no other metal we know today can do so many different kinds of jobs so economically and so well.



A new booklet, "Straits Tin: A Most Useful Metal for American Industry," tells a factual and intriguing story of the many new ways tin can be used today. A copy is yours for the asking.

THE MALAYAN TIN BUREAU

Dept. 354, 1028 Connecticut Ave., Washington 6, D.C.



use with water in still-tank or spray-washing equipment. *Solventol*

1031. Cleaners

Bulletin on alkaline metal cleaners and solvent degreasers. *Park Chemical*

1032. Cleaning

Data sheets on acid activators to promote removal of scale and oxides from steel and iron. *Swift Ind. Chem.*

1033. Cleaning

8-page bulletin on cold solvent tyre metal cleaning machines and parts washers. *Graymills Corp.*

1034. Cleaning

Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey Ferguson*

1035. Cleaning

12-page Bulletin 68 deals with factors to consider in selecting metal cleaning equipment. *Despatch Oven*

1036. Cleaning

32-page booklet on alkaline, solvent, emulsion, acid phosphate cleaning. *E. F. Houghton*

1037. Cleaning Aluminum

Set of seven data sheets on cleaning and finishing of aluminum. *Pennsalt*

1038. Cleaning Stainless

8-page booklet on care and cleaning of stainless steels. *Republic Steel*

1039. Cobalt Alloy

12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

1040. Cold Finished Bars

Engineering bulletin, "New Economies in the Use of Steel Bars". *LaSalle Steel*

1041. Cold Rolled Steels

32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible Steel*

1042. Compressors

12-page bulletin 126-A on application of turbo-compressors to oil and gas-fired equipment used in heat treating, agitation, cooling, drying. Performance curves, capacities. *Spencer Turbine*

1043. Continuous Annealing

Article on continuous production annealing of screws, bolts, rivets. *Sunbeam Corp.*

1044. Controller

12-page catalog 53-10 on stack-type pneumatic controllers for process variables. *Fischer & Porter*

1045. Copper Alloys

New 48-page book contains tables of alloys with composition, typical uses, general, working, mechanical, electrical properties, hardness, ASTM specification numbers. *Revere*

1046. Copper Alloys

64-page book on free-cutting brass, copper and bronze. *Chase Brass*

1047. Corrosion Resistance

20-page bulletin on copper alloys for corrosion resistance. Table gives applicability in 150 media. *Ampeco*

1048. Crystal Models

Folder describes unique kit for constructing crystal models. *Harshaw*

1049. Cutting Oil

Facts on more efficient and economical plant operation through use of right lubricants described in "Metal Cutting Fluids" booklet. *Cities Service*

1050. Cutting Oil Chart

Selection chart for seven classes of metal in nine machining operations. *Aldridge Industrial Oils*

Keep your product on the move

WITH

ASHWORTH PROCESS BELTS

ASHWORTH belts have gained Industry-wide acceptance.

Fabricated from metal of the analysis required for the specific end use, and designed for maximum performance under the most severe operating conditions.

Ask the nearest Ashworth Sales Engineer to help you analyze your problem.



Sintering of Powdered Metal Parts

ASHWORTH BROS., INC.
METAL PRODUCTS DIV. • WORCESTER, MASS.

Sales
Engineers:

Buffalo • Chattanooga • Chicago • Cleveland • Detroit • Kansas City • Louisville
Los Angeles • New York • Philadelphia • Pittsburgh • Rochester • Seattle • St. Paul
Tampa
Canadian Rep., PECKOVER'S LTD. • Toronto • Montreal

WRITE FOR
ILLUSTRATED CATALOG
M-52



Tensile Testing

Fast!
Accurate!
Easy!

This compact machine tests spotwelds, strip, wire, anything within its 20,000 lb. capacity. Hydraulically powered, it has an easily controlled ram, self-acting specimen grips that are open sided for easy specimen insertion. This tester, Model ST-1, is adjustable to take specimens 5" to 9" in length. Various load gauges, grips, and other modifications are available.

Write for more information -
give us your requirements.

DETROIT TESTING MACHINE COMPANY

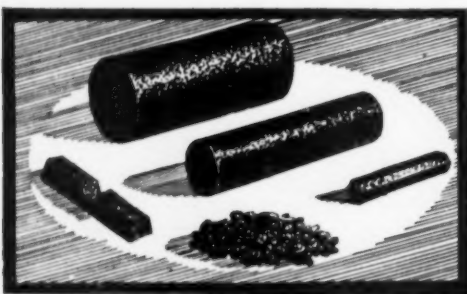
9384 Grinnell Ave., Detroit 13, Mich.

This alloy list keeps getting longer and longer!

Cannon-Muskegon can supply scores of special and standard alloys for remelt or reprocessing, certified to your exact specifications

A long alloy list is an excellent indication of long alloy experience! As source for many of the nation's major investment casting suppliers and others, Cannon-Muskegon furnishes a great variety of alloys for remelt or reprocessing. Alloys include super stainless and tool steels, as well as nickel and cobalt-base alloys. Other alloys are prepared specially for medical, aeronautical, electronic, industrial and experimental uses.

These alloys are in addition to a wide range of carbon and 300 and 400 series stainless steels regularly carried in stock for immediate delivery. Remember . . . no matter what type alloy you specify each is backed with a notarized metal analysis insuring exactly predictable physical, chemical and electrical properties.



MASTERMET ALLOYS are available in either ingot, shot, hexagon bar, billet or 12" long, 6" diameter cast round bar form. Alloys are shipped in drums with specifications clearly imprinted for fast selection and storage.



WRITE for your copy of New MasterMet Bulletin and technical data on the complete MasterMet alloy service.

Cannon-Muskegon CORPORATION

2079 Lincoln Street • Muskegon, Michigan

METALLURGICAL SPECIALISTS



***NI RESIST**

SAE 1020

SAE 4130

SAE 52100

SAE 6150

SAE 8630

AMS 5382B

AMS 5385B

AMS 5388

PWA 651

ARMCO

17-4-PH

4750

AISI

300 SERIES

AISI

400 SERIES

*MONEL

*INCONEL

ACI-H7

18-4-1

IIB2

IID2

INVAR

CO-CR-W

ALLOYS

CU-NI

ALLOYS

NI-CR

ALLOYS

NI-FE

ALLOYS

NI-CR-FE

ALLOYS

CR-FE

ALLOYS

*©International Nickel Co.

1051. Decarb Test

Simple test for decarburization described in Tips and Trends. *Ajax Electric*

1052. Descaling Stainless Steel

Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

1053. Dew Point Control

Bulletin No. 21-C on instrument which indicates, records and controls dew point automatically. *Ipsen*

1054. Die Steel

Bulletins on air-hardening, high-carbon, high-chromium die steel containing sulphide additives. *Latrobe*

1055. Ductile Iron

Reprints on engineering applications of ductile iron and its significance to the foundry industry. *Youngstown Foundry & Machine*

1056. Electric Furnaces

Bulletin on rotary-hearth electric furnaces, with maximum operating temperatures of 1800° F. and 2500° F. for hardening, normalizing, drawing and pack carburizing. *General Electric Co.*

1057. Electric Furnaces

Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

1058. Electric Furnaces

Booklet on four types of electric heating elements and their methods of mounting. *Holcroft*

1059. Electrodes

12-page bulletin on carbon-steel electrodes for use with inert gas shields. *Air Reduction Sales*

1060. Electroplating

8-page bulletin on rectifiers for cleaning, polishing, electroforming, electroplating and anodizing. *Ther Electric & Machine Works*

1061. Electropolisher

Bulletin on theory and practice of electrolytic polishing of metallurgical samples. Description of electropolisher. *Buehler*

1062. Extrusion

16-page bulletin on Koldflo extrusion of parts in one operation. Step-by-step procedure. *Mullins Mfg. Corp., Koldflo Div.*

1063. Ferro-Alloys and Metals

104-page book gives data on more than 50 different alloys and metals produced by the company. *Electro Metallurgical*

1064. Finishing

52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

1065. Flame Hardening

20-page booklet on precision flame hardening machine with electronic control. Details of operation and applications. *Cincinnati Milling Machine*

1066. Flow Meters

24-page manual on application and installation of indicating flow meter. *Meriam Instrument*

1067. Flow Meters

Bulletin 201 on flow meter for gas used in heat treating. *Waukeag Eng'g.*

1068. Forgings

94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

1069. Forming Dies

Folder on styles of forming dies for stainless heads—in wide range of sizes and gages. *Carlson*

1070. Forming Equipment

Bulletin on machinery and equipment for cold roll forming. *American Roller Die*

1071. Foundry

36-page illustrated booklet dealing with foundry products, procedures and craftsmanship. *Lebanon Steel Foundry*

1072. Foundry Equipment

New 16-page bulletin on various models of mold and core machines, their operation and installation. *Beardsley & Piper*

1073. Foundry Refractories

30-page catalog of refractories for foundry use includes sections on cupola block manufacture, ladle refractories, slag and breast block, etc. *Laclede-Christy*

1074. Fuel Gas

Bulletin on "Pyrofax" gas for cutting, brazing, metallizing, flame hardening, carburizing and heat treating. *Pyrofax Gas Co.*

1075. Furnace Belts

44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

1076. Furnace Charging

12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

1077. Furnace Construction

12-page bulletin on thin-wall construction for furnace enclosures. Engineering drawings. *Bigelow-Liptak*

1078. Furnace Controls

Catalog 53-1 on furnace and oven controls including temperature controllers, recorders and indicators and safety control equipment. *Minneapolis-Honeywell*

1079. Furnace Controls

22-page booklet on instruments and controls for heat treating furnaces. *Hays Corp.*

1080. Furnace Fixtures

16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

1081. Furnaces

Folder describes complete set-up for heat treatment of small tools, including draw furnace, quench tank and high temperature furnace. *Waltz Furnace*

1082. Furnaces

40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

1083. Furnaces

12-page brochure on car furnaces of special and conventional design. *Jet Combustion*

1084. Furnaces

High temperature furnaces for temperatures up to 2000° F. are described in bulletin. *Carl-Mayer Corp.*

1085. Furnaces

Bulletin No. 200 on multi-burner heat treating furnace. *Am. Gas Furnace*

1086. Furnaces, Heat Treating

32-page catalog no high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

1087. Furnaces, Heat Treating

Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

1088. Furnaces, Heat Treating

Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

1089. Furnaces, Heat Treating

12-page bulletin on conveyor furnace.



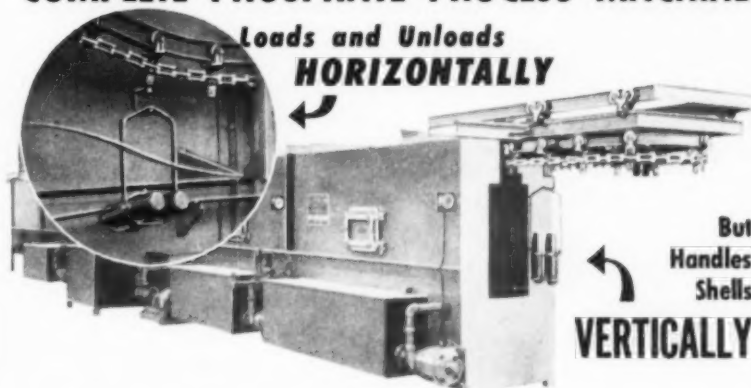
The parts are all made and on their way. Now I can go on my vacation thanks to you Pete and your favorite Columbia ATMODIE.

COLUMBIA TOOL STEEL COMPANY • CHICAGO HEIGHTS, ILL.

Producers of fine tool steels — All types immediately available through Sales Offices, Warehouses and Representatives in Principal Cities.



NEW ALVEY-FERGUSON 5-STAGE COMPLETE PHOSPHATE PROCESS MACHINE



BECAUSE a vertical position in the finish-cleaning operation assures a more uniform spray coverage and more complete drainage—

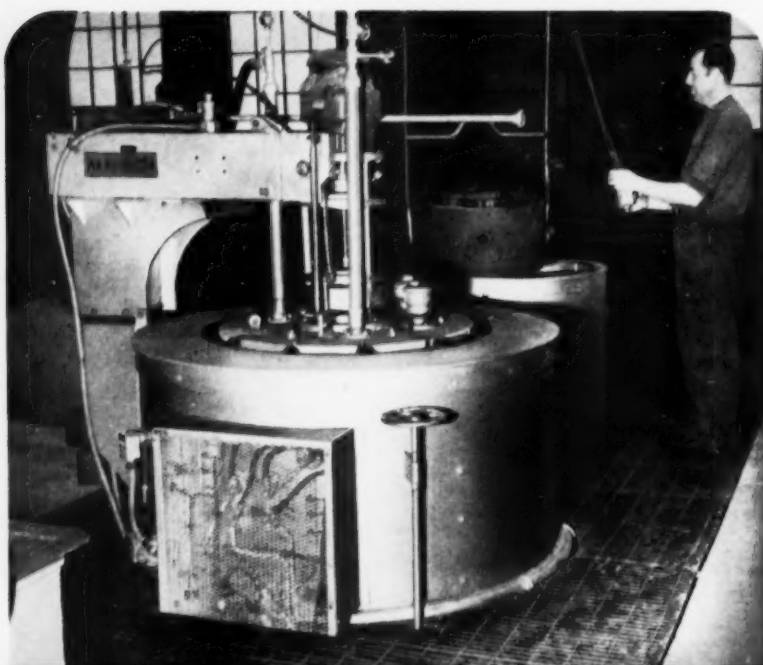
... BUT a horizontal position at the loading and unloading stations permits the operator to slide the 120 M M shells to and from a storage table or belt conveyor into—and out of—the trolley conveyor attachments without lifting the shells ...

... Alvey-Ferguson designed this Phosphate Processing Machine with Special Hinged Type Fixtures which speeds up the cleaning and surface-preparation-for-paint operations to 360 shells per hour.

Alvey-Ferguson Engineers solve many tough-to-crack-problems in the metal products cleaning field. May we help you solve yours? Write without obligation—today.

THE ALVEY-FERGUSON CO., 166 Disney St., Cincinnati 9, Ohio

Offices or Representatives in Principal Cities.



CARBURIZING TIME CUT 4 HOURS with a

HEVI-DUTY

FURNACE

Electrol Inc., manufacturers of hydraulic devices, carburizes landing gear orifice tubes in 3 hours instead of 7 hours formerly required by the pack method.

Edgar B. Roesch, Factory Manager, says, "With this Hevi Duty Retort Furnace, we can produce a more uniform case faster because —

Forced Circulation assures even case depth throughout the densest loads.

Zone Temperature Control helps bring the load up to temperature more quickly and evenly.

Positive Pressure inside the retort has simplified the obtaining of exact carbon concentrations on the surface of the work and to specified depths."

The carburizing atmosphere is supplied from a Hevi Duty Endothermic Generator to which natural gas is added.

This atmosphere protects the work from scaling which results in a further saving of 50% in surface finishing time.

Write for Bulletin HD-646-R and more information about how the Hevi Duty Retort Furnace is used for carburizing, hardening, nitriding, and bright annealing.



HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers Constant Current Regulators

radiant tube gas heated, oil or electrically heated. Electric Furnace Co.

1090. Gear Hardening

Folder on application of induction heating to high-production hardening of gears. Westinghouse

1091. Globar Furnaces

Bulletin 153 describes nine types of furnace using silicon carbide heating elements for temperatures to 2600° F. Hevi Duty

1092. Gold Plating

Folder on salts for bright gold plating. Also lists equipment needed. Sel-Rex

1093. Graphite Electrodes

Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. Great Lakes Carbon Corp.

1094. Graphitization

12-page booklet discusses graphitization from the standpoint of temperature, chemical composition, deoxidation practice, pre-welding microstructure, welding conditions, post-weld heat treatment, stress and strain. Edward Valves

1095. Handling Devices

Pamphlets on clamps for lifting and handling. Their application to various industries. Merrill Bros.

1096. Hardening Stainless

24-page "Story of Malcomizing" describes surface hardening of stainless steels. Lindberg Steel Treating Co.

1097. Hardness Tester

Booklet describes two models of Penetroscope hardness testers. C. Tennant

1098. Hardness Tester

20-page bulletin on use of portable hardness testers and accessories. Ames Precision Machine

1099. Hardness Tester

4-page bulletin on Brinell hardness tester weighing 26 lb. for portable and stationary use. Andrew King

1100. Hardness Tester

20-page book on hardness testing by Rockwell method. Clark Instrument

1101. Hardness Tester

Catalog of testers for normal hardness, superficial testing, accessory and special testing and micro and macro hardness testing. Wilson Mechanical Instrument

1102. Hardness Tester

Data on portable hardness tester for Rockwell readings. Riehle

1103. Heat Processing

Bulletin answers questions: what is to be heated, what sections are to be heated, why the material is to be heated, to what temperature and for how long. Selas

1104. Heat Resistant Alloy

10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. Rolled Alloys

1105. Heat Resistant Alloy

Pyrasteel bulletin describes chromium-nickel-silicon alloy for service economy in resisting oxidation and corrosion to 2000° F. Chicago Steel Foundry

1106. Heat Resistant Alloy

Bulletin No. 1 on HR-3 (37% Ni, 17% Cr) cast alloy for parts subject to corrosion and high temperatures. Standard Alloy

1107. Heat Treating

Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. Young Bros.

1108. Heat Treating

Handy, vest-pocket data book has 72

pages of charts, tables, diagrams and factual data on steel specifications, heat treatments, etc. *Sunbeam*

1109. Heat Treating

Catalog N-35 on furnaces for hardening high speed steel. *Sentry Co.*

1110. Heat Treating

56-page "Heat Treating Alloy Steels". *Republic Steel*

1111. Heat Treating

Bulletin 850 on shaker-hearth furnace for bright carburizing, carbonitriding, hardening. *Hevi Duty Electric*

1112. Heat Treating

Data on how to heat, quench, wash and temper automatically. *Metalwash Machinery*

1113. Heat Treating Ammonia

24-page "Guide for Use of Anhydrous Ammonia" describes heat treating and other metallurgical uses. *Nitrogen Div.*

1114. Heat Treating Baskets

12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex Mfg.*

1115. Heat Treating Equipment

New folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

1116. Heat Treating Fixtures

24-page catalog B-8 on muffles, retorts, baskets, other fixtures for heat treating in gas or salt baths. *Rolock*

1117. Heat Treating Fixtures

Folder shows 21 examples of heat treating fixtures, trays, baskets, retorts. *Allied Metal Specialties*

1118. Heat Treating Fixtures

24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

1119. Heat Treating Guide

Chart guide constructed on slide rule principle for simplified hardening and drawing of tool steels. *Carpenter Steel*

1120. Heat Treating Pots

6-page bulletin lists sizes available in Thermalloy. Suggestions on increasing service life. *Electro-Alloys*

1121. Heat Treating Pots

Bulletin 110 gives data on sizes and shapes of cast nickel-chromium solution pots. *Fahratloy*

1122. Heat Treating Pots

Bulletin on heat and corrosion resistant metallized pots. *Eclipse Fuel Engineering*

1123. High-Alloy Castings

Bulletin 3150-G on castings for heat, corrosion, abrasion resistance. *Duraloy*

1124. High-Temperature Steels

87-page book on factors affecting high-temperature properties. 45 pages of data on tensile, creep and rupture properties of 21 high-temperature steels. *U. S. Steel*

1125. High-Tensile Steel

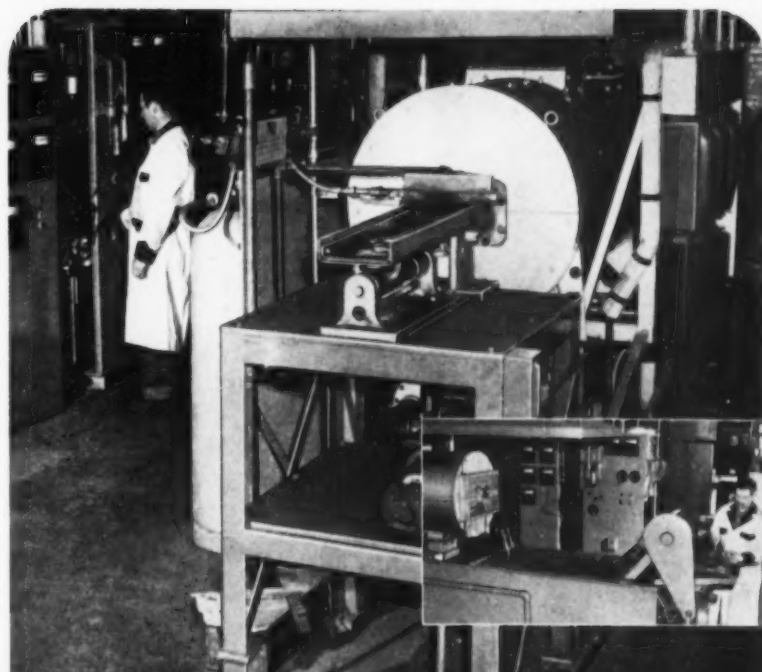
Bulletin on nickel-copper steel of low-alloy, high-strength type. *Youngstown Sheet and Tube*

1126. High-Vacuum Pumps

Data sheet on physical dimensions, operating data and performance curves for high-vacuum oil diffusion pumps. *Consolidated Vacuum Corp.*

1127. Identifying Stainless

Cardboard chart outlining systematic method for rapid identification of unknown or mixed stocks of stainless steels. *Carpenter Steel*



Do ALL PRECISION GAGE BLOCKS... HARDENED

with a

HEVI-DUTY

SHAKER HEARTH FURNACE

Gage blocks, industry's standard of precision measurement require accuracies within millionths, hardness adequate to resist wear and freedom from distortion and warpage. DoALL Gage Blocks, distinguished throughout the world for excellence, are heat treated to meet rigid specifications. —

- No Distortion
- No Warpage
- No Scale
- Hardness 65-66 Rockwell C

The Hevi Duty Shaker Hearth Furnace treats to these specifications because—



The heating time cycle can be accurately set.

Zone temperature control regulates heating rate and maintains exact quenching temperature.

A prepared atmosphere and enclosed quench protect the blocks from scaling.

Each part receives individual yet uniform treatment on a mass production basis.

Write for Bulletin HD-850 and more information how this modern furnace can solve your heat treating problems.

HEVI DUTY ELECTRIC COMPANY

MILWAUKEE 1, WISCONSIN

Heat Treating Furnaces... Electric Exclusively
Dry Type Transformers Constant Current Regulators



At the '54 Metal Exposition—Nov. 1-5 . . .
50,000-PLUS METALS INDUSTRIES MEN
WILL LEARN NEW WAYS OF CUTTING COSTS!

Your competitors . . . thousands of 'em . . . will be on hand at this great industrial event to check closely on everything that's new and improved . . . everything that will help them build better products . . . cheaper . . . faster!

They'll come from all corners of the land . . . these 50,000-plus metals industries men . . .

and they'll take away with them, when this great Metal Show ends, more ideas . . . more information and more know-how than any 'stay-at-home' executive could possibly match!

Owned and Managed by
AMERICAN SOCIETY FOR METALS
 W. H. Eisenman Chester L. Wells
Managing Director *Ass't. Director*

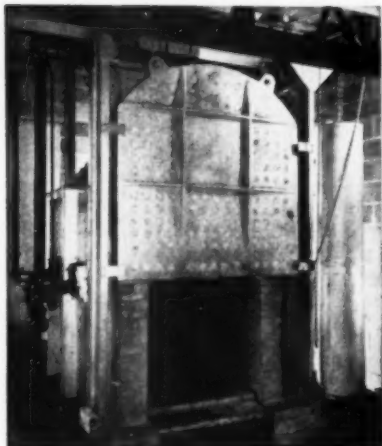
INTERNATIONAL AMPHITHEATRE
CHICAGO **NOV. 1-5**

NATIONAL METAL
EXPOSITION

NATIONAL METAL
CONGRESS

HEAT TREATING FURNACES

UP TO 2000°F. OR MORE



This car-type annealing furnace is an example of the heat treating furnaces designed and engineered by the Carl-Mayer Corp. This particular car bottom furnace was designed for the heat treatment of chain up to 2000°F. at Cleveland Chain & Mfg. Co. We also build furnaces for other uses, including aluminum and magnesium heat treating.

• • •



This battery of three aging ovens incorporates direct gas-fired recirculating air heating systems and other features which contribute to uniformity and faster, more economical production in a large aluminum company.

• • •

Investigate the advantages and patented features offered in the heat treating furnaces and ovens designed and built by the Carl-Mayer Corp.—write for the new, illustrated folder today. Bul. HT-53.

THE CARL - MAYER CORP.
3030 Euclid Ave., Cleveland, Ohio

1128. Induction Heat Control

Data sheet on radiation pyrometer for direct measurement of work being induction heated. *Leeds & Northrup*

1129. Induction Heating

Bulletin on high frequency induction heaters. Application and equipment. *Electric Arc*

1130. Induction Heating

36-page catalog on high-frequency induction heating. *Lepel*

1131. Induction Melting

8-page article describes use of induction melting in improved technique for rotor-casting. *Ajax Engineering*

1132. Induction Melting

16-page booklet 14-B on high-frequency converter type furnaces for induction heating and melting of ferrous and non-ferrous metals. *Ajax Electrothermic*

1133. Industrial Radiography

Booklet gives recommendations on planning and construction of a betatron industrial radiograph laboratory. *Allis-Chalmers Mfg.*

1134. Instruments

Bulletin F-5633-1 on instruments for industrial process control. *Wheelco*

1135. Instruments

New 24-page catalog 5001 on industrial instruments and equipment. *Minneapolis-Honeywell*

1136. Insulation

40-page industrial products catalog on insulations, refractory products, and others. *Johns-Manville*

1137. Iron Powder

Bulletin on production of iron powder for flame cutting, scarfing, powder metallurgy, electronics and chemical applications. *Easton Metal Powder Co.*

1138. Laboratory Furnace

Box furnace with cooling chamber for use to 3100° F. described in bulletin GEA-4713. *General Electric*

1139. Laboratory Furnaces

Data sheets on complete line of laboratory furnaces for metallurgical operations. *Boder Scientific*

1140. Leaded Steel

Bulletin on analysis and advantages of cold finished leaded steel bars. *LaSalle Steel*

1141. Leaded Steel

8-page bulletin gives chemical composition, mechanical properties and case studies showing machining production rates of Ledloy, lead bearing steel. *Ryerson*

1142. Leaded Steel

Engineering memorandum on Ledloy-A, free machining, lead bearing steel. *Peter A. Frasse*

1143. Low-Alloy Steel

60-page book on high-strength low alloy steel, properties, fabrication and uses. *U. S. Steel*

1144. Low-Temperature Properties

48-page bibliography of characteristics of steels at low temperature covers 1904 to June 1953. *Inco*

1145. Lubricant

New catalog, No. 460, on how colloidal dispersions serve industry. *Acheson Colloids*

1146. Lubricant

New literature on anti-seize molybdenum disulfide lubricant. *Bel-Ray*

1147. Lubricant

8-page folder describes use of molybdenum disulfide lubricant in cold form-



Need Impregnation?

You've got an impregnation problem, and you need help... Why waste time with hit-and-miss methods — come to the expert, your Metaseal impregnation engineer.

Check your nearest American Metaseal plant:

- ☐ LOS ANGELES
- ☐ TULSA
- ☐ DETROIT
- ☐ MUSKOGON, MICH.
- ☐ CLEVELAND
- ☐ BUFFALO
- ☐ ROCHESTER, N. Y.
- ☐ PHILADELPHIA
- ☐ BALTIMORE
- ☐ WEST NEW YORK, N. J.
- ☐ EAST HAVEN, CONN.
- ☐ SOMERVILLE, MASS.
- ☐ MONTREAL, CAN.

Metaseal's 100% guaranteed impregnation process completely penetrates all pores, assures permanent pressure-tightness, corrosion prevention, and end of finish failures. The American Metaseal plant nearest you has the solution to your impregnation problem.

Write today for quick action

American Metaseal Mfg. Corp.
607 Sixty-fifth Street, West New York, N. J.

METASEAL

High-Purity Fused Alumina Grains...

What Can They Do For You?

FUSED alumina, with its inherent properties of hardness, chemical stability and high density, is one of the most widely used electrochemically refined materials. It is produced in many forms. One of these, Norton 38 ALUNDUM* grain has proved successful for many applications demanding high purity. Electrically fused from Bayer-processed alumina, this white grain is shown by typical chemical analysis to be 99.49% pure Al_2O_3 . It is insoluble in common solvents and extremely resistant to reduction. It is an amphoteric refractory and has high dielectric strength. Other characteristics include:

Melting point — about 3600°F.
Specific gravity — 3.94
Crystal structure — hexagonal system (rhombohedral division)
Hardness — 9.0 Mohs' scale
Index of refraction — 1.76 mean

Typical uses of 38 ALUNDUM grain are: pure oxides and sintered refractories, refractory cements, catalyst supports, heat exchange pebbles, wear-resistant parts, laboratory ware.

Other types of Norton fused alumina with unique combinations of properties which make them highly suitable for special requirements include:

38500 and 38900 AWIF ALUNDUM Grains

In these further refinements of 38 ALUNDUM grain, the terminal designations 500 and 900 indicate particle sizes. In the 38500 grain, average and maximum particle sizes are 19.5 microns and 50 microns, respectively; in the 38900 grain average and maximum particle sizes are 7.5 microns and 30 microns, respectively. Particle sizes are consistently very uniform. AWIF signifies "acid-washed and iron-free."

Although these grains have the same physical properties as 38 ALUNDUM grain, their special processing to remove objectionable elements results in unusually

high purity. A typical chemical analysis reveals:

Al_2O_3 — 99.86% • Fe_2O_3 — .01 to .05%
 SiO_2 — .01 to .05% • Na_2O — .01 to .08%
C — <.01% • pH — >4.1

Very good electrical resistance, high heat conductivity and inertness are further advantages of 38500 and 38900 ALUNDUM grains for applications in both the electrical and chemical fields. In addition to their use in electronic tubes, as illustrated, other possible uses include the manufacture of ceramic pieces, particularly electronic components where the inherent qualities of this extremely pure grain are of great value.

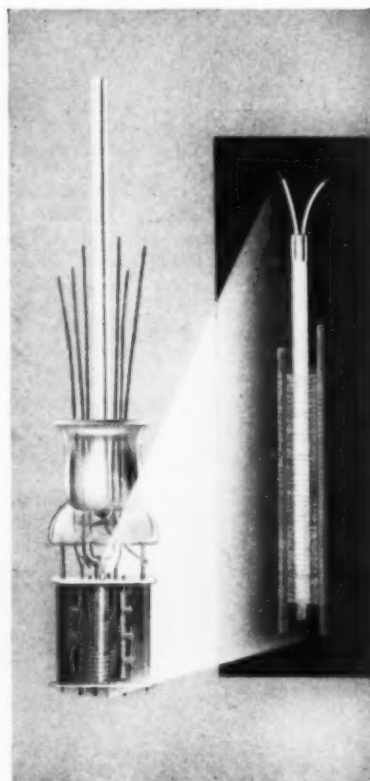
Other Norton Electrochemically Refined Materials

We made ALUNDUM grains the subject of this message. But we could just as well have chosen any of the long list of well known Norton electric furnace materials — CRYSTOLON* silicon carbide, MAGNORITE* magnesium oxide, NORBIDE* boron carbide, FUSED STABILIZED ZIRCONIA, and many others, including a number still undergoing research and development.

These high-melting materials which have varied applications in many fields, are also the basic ingredients of the famous Norton Refractory B's — refractories engineered and prescribed for the widest range of uses.

For Your Own Applications or Developments

Norton Company not only supplies these materials in their crude form, but has extensive facilities for processing and fabricating — and is ready to work with you in engineering materials to your particular requirements. A new booklet "Norton Refractory Grain Electrochemically Refined" contains detailed information on these interesting materials. NORTON COMPANY, 328 New Bond Street, Worcester 6, Mass.



IN ELECTRONIC TUBES Norton 38500 or 38900 ALUNDUM fused alumina grain is used to coat heater filament tubes (shown enlarged). The grain is put in suspension and the filament is drag coated, spray coated or electrically deposited (cathodoresis).

NORTON
REFRACTORIES

Engineered... *R*... Prescribed

*Making better products...
to make other products better*

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

ing, cold heading and other applications. Case histories. *Alpha Corp.*

1148. Lubricant Application

Bulletin on method of bonding dry molybdenum disulphide films on bearing surfaces by tumbling. *Alpha Corp.*

1149. Magnesium

42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

1150. Magnesium Castings

5-page reprint tells of new developments in making magnesium castings for aircraft needs. *Dow Chemical*

1151. Magnesium Extrusions

36-page bulletin gives values for moment of inertia, section modulus and radius of gyration of bars, tubing, angles, channels, tees, zeels and other sections. *Dow Chemical*

1152. Master Alloys

Bulletin on custom-made alloys for remelt or reprocessing. *Cannon-Muskegon*

1153. Melting Aluminum

Bulletin 310 on furnaces for melting aluminum. *Lindberg Eng'g.*

1154. Metal Detector

Catalog on detector for any kind of metal or alloy. *RCA*

1155. Metallographic Equipment

12-page catalog E-29 describes bright-field equipment for visual observation and photography. *Bausch & Lomb*

1156. Meters and Controls

New 16-page Bulletin 17 on basic specifications for measuring, transmitting, receiving, interpreting and controlling 18 variables normally encountered in production. *Bailey Meter*

1157. Microhardness Tester

Bulletin describes the Kentron microhardness tester. *Torsion Balance Co.*

1158. Moly-Sulphide Lubricant

40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

1159. Nitriding

48-page booklet on nitralloy and nitriding, including the new Floe process. Types of nitriding steels, surfaces not to be hardened, weldability. *Nitralloy Corp.*

1160. Nitrogen Atmosphere

Bulletin on generator for producing pure nitrogen with a controllable hydrogen content. *Baker & Co.*

1161. Nonferrous Tubing

Bulletin on seamless, brazed and lock-seam tubing in brass and copper. *H & H Tube and Mfg.*

1162. Nonferrous Wire

Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

1163. Openhearth

Brochure on modern openhearth design and construction. *Loftus*

1164. Pickling Baskets

Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

1165. Pickling Baskets

12-page bulletin on mechanical picklers, crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

1166. Pipe and Tubing

68-page book on pipe and tube making, answering many pertinent questions on
(Continued on page 32-A)

New WAUKEE FLO-METERS

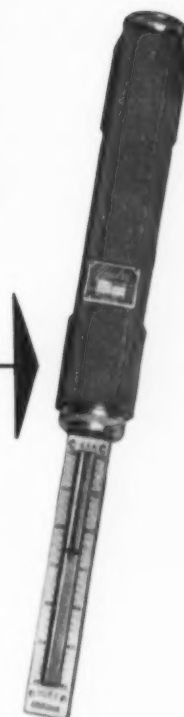
for accurately measuring air . . ammonia . . dissociated ammonia . . butane . . city gas . . endothermic cracked . . exothermic cracked . . hydrogen . . natural gas . . nitrogen . . oxygen . . propane.

Here's the most important advance in flow-meter design and construction in the last 20 years . . the new WAUKEE FLO-METER!

It's easier to see flow changes. It's easier to read . . has 6" scale. It's easier to clean . . complete hand disassembly takes only seconds.

It's easier to mount . . new design permits panel mounting, simpler piping. It has built-in control valves.

And you'll like the Waukee's streamlined appearance. For additional information request bulletin #201.



Waukee

ENGINEERING COMPANY

403 E. Michigan St., Milwaukee, Wis.



NEW
LM
EDGEWOUND
WASHERS

Now

NO TANGLE - NOTCH COIL
WASHERS SNAP OFF COIL
PREPLACE ON WORK

- ★ Produced from standard wire stocks. No lead time needed for dies or exact strip.
- ★ Suitable for use with induction, gas-air, furnace, or any of the commonly used heating methods.
- ★ Available in EASY FLO and SILFOS as well as Copper, Bronze and other alloys.
- ★ Diameters up to 4" I.D., wire thicknesses from .010 upward.



LUCAS-MILHAUPT
ENGINEERING CO.

5056 S. LAKE DRIVE, CUDAHY, WISCONSIN

FREE 10 page booklet gives you all the facts on better brazing with preforms. Write Today!

IPSEN

endothermic

GENERATORS

GAS- FIRED

A complete line of Ipsen Generators, gas-fired, with output capacities ranging from 250 to 5000 C.F.H. is now available with all of the proven features of other Ipsen electric endothermic units. Specific features of the gas-fired models include multi-jet burners and an inconel retort, automatic temperature control of water-cooled heat exchanger, double exhaust vents, and automatic protective devices that assure efficient operation within a safe temperature range.

FREE BULLETIN—Write for complete data and specifications on these new units today.

Ipsen Model G-1250-G Gas-Fired Generator

Universal Production Units in Standard Sizes 100 to 2000 LB./HR.

IPSEN INDUSTRIES, INC. 723 SOUTH MAIN STREET, ROCKFORD, ILLINOIS

Ipsen
AUTOMATIC
HEAT TREATING UNITS



This Holcroft Book belongs in **YOUR** Technical Library



"We are going to invest in our own heat treat furnace. Where should we start—what furnace facts should we know?"

"Do we know the difference between 'direct' and 'indirect' firing?"

"Do we know all the methods of handling stock, and which would best suit our needs?"

Questions like these are best answered by a manufacturer who specializes in building furnaces for specific jobs. You'll find the answers—compiled from a world of experience—in Holcroft's book "Blazing the Heat Treat Trail."

For example, there's a frank discussion of all of the basic factors that govern the selection of a furnace: the fuel to use, a discussion of open firing versus controlled atmospheres, an illustrated section on stock handling, and suggestions as to how your heat treat process can be tied right into the production line.

This book represents the type of industry service that stamps Holcroft as its leader. As continuing sources of information, future advertisements will further describe different furnace types and methods of handling stock.

You'll find it's a good bet to come to Holcroft first!

Want a copy of this book for your files? Just write—right now!

Holcroft & Company, 6545 Epworth Blvd., Detroit 10, Michigan.

HOLCROFT & COMPANY **PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE**
6545 Epworth Blvd. **Detroit 10, Michigan**

CHICAGO, ILL. CLEVELAND, OHIO HOUSTON, TEXAS PHILADELPHIA, PA.
CANADA: Walker Metal Products, Ltd., Windsor, Ontario EUROPE: S.O.F.I.M. Paris 8, France

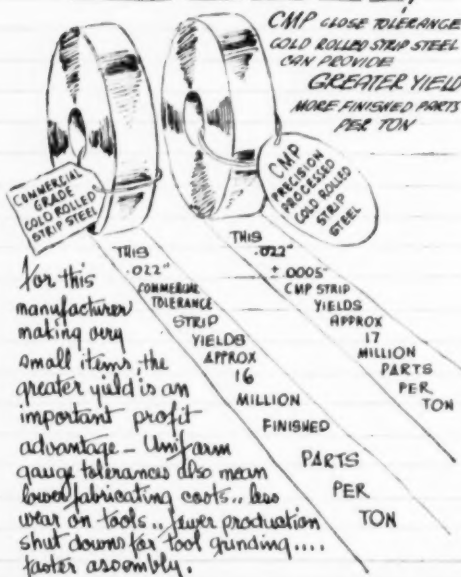


CMP COLD ROLLED STRIP STEEL

OFFERS some realistic ways to reduce end-product costs THROUGH PRECISION GAUGE TOLERANCES

Typical Case

1,000,000 MORE PARTS PER TON!



Having ear trouble? If your drawn product requires trimming to remove ears or scallops, you may be able to reduce your end-product cost by the use of CMP non-earing (non-scalloping) cold rolled strip steel. This is one of many ways in which CMP engineers specifications and processing methods to enable strip steel users to produce better products at lower cost.

Perhaps we can help you to reduce end-product cost without capital investment.



the Cold Metal Products co.

GENERAL OFFICES: YOUNGSTOWN 1, OHIO

PLANTS: YOUNGSTOWN, OHIO AND INDIANAPOLIS, INDIANA

SALES OFFICES: New York • Cleveland • Detroit • Indianapolis • Chicago • St. Louis • Los Angeles • San Francisco

LOW CARBON, HIGH CARBON (Annealed or Tempered), STAINLESS AND ALLOY GRADES, ELECTRO ZINC COATED ARE AVAILABLE FROM:

THE COLD METAL PRODUCTS CO. OF CALIFORNIA

6600 McKinley Avenue, Los Angeles Phone: Pleasant 3-1291

THE KENILWORTH STEEL CO., 750 Boulevard, Kenilworth, New Jersey

Phones: N. Y., COntlandt 7-2427; N. J., UNionville 2-6900

PRECISION STEEL WAREHOUSE, INC.

4425 W. Kinzie, Chicago

Phone: COLUMbus 1-2700

1206. Stainless Steel

44-page book gives detailed information on use of stainless steel in the chemical industries. *Crucible Steel*

1207. Stainless Steel

36-page bulletin on effect on properties of processing at different temperatures. *International Nickel*

1208. Stainless Tubing

28-page book on corrosion, uses and fabrication of stainless steel tubing. *Steel and Tubes Div., Republic*

1209. Steel 52100

New stock list on 52100 tubing, bars, and ring forgings. *Peterson Steels*

1210. Steel 52100

Data sheet on high-purity 52100 steel, made by vacuum melting. *Vacuum Metals*

1211. Strip Mill Equipment

Bulletin on units and assemblies for cleaning, annealing, pickling and drying strip. *W. S. Rockwell*

1212. Subzero Freezer

Data on chest for use down to -95° F. for production use and testing. *Revco*

1213. Subzero Tests

62-page bulletin on equipment for low-temperature tests. *Bowser Technical Refrigeration*

1214. Temperature Control

36-page bulletin P 1245 on new electronic instruments for recording and indicating variables. *Bristol Co.*

1215. Tempering

Bulletin IE-11 on tempering and other applications in liquid baths. *Kemp*

1216. Tempilstiks

"Basic Guide to Ferrous Metallurgy", a plastic laminated wall chart in color. *Claud S. Gordon*

1217. Testing Machines

Universal testing machines and equipment are diagramed, described and illustrated in 20-page Bulletin 43. *Tinius Olsen*

1218. Testing Machines

32-page catalog on hydraulic testing machines. 10 models described; also accessories. *Riehle*

1219. Textured Metal

16-page booklet on advantages and applications of textured metal. *Rigidized Metals*

1220. Thermocouples

44-page catalog EN-S2 describes couples

September, 1954

950	975	1000	1025	1050	1075	1100	1125
951	976	1001	1026	1051	1076	1101	1126
952	977	1002	1027	1052	1077	1102	1127
953	978	1003	1028	1053	1078	1103	1128
954	979	1004	1029	1054	1079	1104	1129
955	980	1005	1030	1055	1080	1105	1130
956	981	1006	1031	1056	1081	1106	1131
957	982	1007	1032	1057	1082	1107	1132
958	983	1008	1033	1058	1083	1108	1133
959	984	1009	1034	1059	1084	1109	1134
960	985	1010	1035	1060	1085	1110	1135
961	986	1011	1036	1061	1086	1111	1136
962	987	1012	1037	1062	1087	1112	1137
963	988	1013	1038	1063	1088	1113	1138
964	989	1014	1039	1064	1089	1114	1139
965	990	1015	1040	1065	1090	1115	1140
966	991	1016	1041	1066	1091	1116	1141
967	992	1017	1042	1067	1092	1117	1142
968	993	1018	1043	1068	1093	1118	1143
969	994	1019	1044	1069	1094	1119	1144
970	995	1020	1045	1070	1095	1120	1145
971	996	1021	1046	1071	1096	1121	1146
972	997	1022	1047	1072	1097	1122	1147
973	998	1023	1048	1073	1098	1123	1148
974	999	1024	1049	1074	1099	1124	1149

and assemblies for general application and for special plant and laboratory uses. Tabular data on accuracy and limits of couples. *Leeds & Northrup*

1221. Tin

20-page booklet describes mining of tin and its present use by American industry. *Malayan Tin Bureau*

1222. Titanium Tubing

Bulletin No. 42 on properties, applications and advantages of titanium tubing. *Superior Tube Co.*

1223. Tool Steel

60-page booklet on high-speed, hot work, cold work, shock resisting, carbon and low-alloy tool steels. *Jessop*

1224. Tool Steel

Bulletin on precision-ground oil-hardening and air-hardening tool steel flat stock. *Jessop*

1225. Tool Steel

20-page booklet on selection of proper tool steel support material for use with carbide tools. *Allegheny Ludlum*

1226. Tool Steel Failures

124-page book, "Tool Steel Trouble Shooter", analyzes 107 tool failures and assigns causes as among tool design faults, tool steel faults, improper heat treatment, mechanical and operational factors. *Bethlehem Steel*

1227. Tool Steel Selector

Twist the dial of the 9-in. circular selector and read off the tool steel for your application. *Crucible Steel*

1228. Tool Steel Tubing

4-page bulletin on high carbon steel small diameter tubing. Recommended heat treatments, chemical composition, mechanical properties, production limits, tolerances and applications. *Superior Tube*

1229. Tubing

52-page "Handbook of Seamless Steel Tubing," 26 pages of data. *Timken*

1230. Tubing Failures

46-page book on tube life in high-pressure high-temperature applications. Results of a great number of investigations of failures. *Babcock & Wilcox*

1231. Tungsten Alloy

Data on properties and uses of 95% tungsten alloy, balance nickel and copper. *Firth Sterling*

1232. Tungsten Electrodes

Folder on inert gas welding techniques

using tungsten electrodes. *Sylvania Electric*

1233. Ultrasonic Cleaning

Folder on Sonogen ultrasonic generator for metal cleaning. *Branson*

1234. Vacuum Calculator

Slide rule for quick calculation of data necessary in vacuum engineering and processing—for instance, pump capacities and time to reach given vacuum. Pertinent conversion tables on back. *F. J. Stokes Machine*

1235. Vacuum Gage

Folder GEC 986 on molecular vacuum gage for measuring pressures without external detectors. *General Electric*

1236. Vacuum Metallurgy

Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. *National Research Corp.*

1237. Vacuum Pumps

24-page Bulletin V51 on high-vacuum pumps and accessories. *Kinney Mfg.*

1238. Valves

New 16-page catalog on two types of goggle valves for blast furnace and coke oven gas mains. *Salem-Brosius*

1239. Welding

Three bulletins on recently developed Fillerarc consumable - electrode gas-shielded welding process. *General Electric*

1240. Welding Alloy Steel

44-page Data Book 4D covers all types of welding of nickel alloy steels. *International Nickel*

1241. Welding Electrodes

New 24-page booklet on welding electrodes for stainless steels. Metallurgy of stainless steels, composition and uses of different electrode grades. *A. O. Smith*

1242. Welding Equipment

Catalog on Cadweld process and arc-welding accessories. *Erico Products*

1243. Zinc and Cadmium Plate

Technical data sheets on use of Luster-on salts for zinc and cadmium plating. *Chemical Corp.*

1244. Zirconium

26-page booklet gives physical, mechanical and chemical properties, present and potential uses, supply and prices of zirconium. *Zirconium Metals*

METAL PROGRESS,

7301 Euclid Avenue, Cleveland 3, Ohio

Please have literature circled at the left sent to me.

Name _____

Title _____

Company _____

Address _____

City and State _____

Postcard must be mailed prior to Dec. 1, 1954
Students should write direct to manufacturers.

Number, 1954

1100	1125	1150	1175	1200	1225
1101	1126	1151	1176	1201	1226
1102	1127	1152	1177	1202	1227
1103	1128	1153	1178	1203	1228
1104	1129	1154	1179	1204	1229
1105	1130	1155	1180	1205	1230
1106	1131	1156	1181	1206	1231
1107	1132	1157	1182	1207	1232
1108	1133	1158	1183	1208	1233
1109	1134	1159	1184	1209	1234
1110	1135	1160	1185	1210	1235
1111	1136	1161	1186	1211	1236
1112	1137	1162	1187	1212	1237
1113	1138	1163	1188	1213	1238
1114	1139	1164	1189	1214	1239
1115	1140	1165	1190	1215	1240
1116	1141	1166	1191	1216	1241
1117	1142	1167	1192	1217	1242
1118	1143	1168	1193	1218	1243
1119	1144	1169	1194	1219	1244
1120	1145	1170	1195	1220	
1121	1146	1171	1196	1221	
1122	1147	1172	1197	1222	
1123	1148	1173	1198	1223	
1124	1149	1174	1199	1224	

(Continued from page 31)

tube mill operation and production. Engineering data and specifications. *Yoder Co.*

1167. Plating

16-page instruction bulletin on bright silver plating process. *Hanson-Van Winkle-Munning*

1168. Plating

Bulletin CR-110-5 describes equipment, bath, operating conditions and control of high-speed chromium plating process. *United Chromium*

1169. Plating of Aluminum

Recent developments, factors affecting plating techniques, recommended procedures, in "Technical Advisor" No. 23. *Reynolds Metals*

1170. Precision Casting

Bulletin on how precision casting is done. Typical castings. *National Precision Casting Corp.*

1171. Precision Casting

44-page Catalog 53 covers every stage of the investment casting process. *Alexander Saunders*

1172. Precision Castings

20-page book on alloys used, specification ranges, advantages and castings made by precision casting. *Haynes Stellite*

1173. Protective Coating

New folder on brush Alodine protective coating for aluminum. *American Chemical Paint*

1174. Pyrometer Supplies

56-page Users' Manual and Buyers' Guide. Specifications, prices, thermocouple calibration data. *Bristol Co.*

1175. Quenching

New catalog on two small self-contained quenching units. *Bell & Gossett*

1176. Quenching Oil

10-page book on new oils for the quenching process gives results on hot wire quench test and in plant operation. *Sinclair Refining Co.*

1177. Quenching Oil

8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

1178. Radiography

28-page booklet on products for industrial radiography gives exposure and processing data for various films used. *DuPont*

1179. Radiography

16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

1180. Radiography

Bulletin 400-319 on self-contained X-ray unit for mass production inspection of parts. *Westinghouse*

1181. Rare Earths

8-page Progress Report Number 1, "Rare Earths in Iron and Steel Melting". *Molybdenum Corp.*

1182. Refractories

12-page bulletin on six types of insulating brick, how to insulate, thermal data. *Harbison-Walker Refractories*

1183. Refractories

32-page booklet on plastic refractory and its use in soaking pits, car bottom furnaces, blast furnaces, openhearth. *Ramite*

1184. Refractories

123-page handbook of refractories discusses research and quality control, standard and series shapes, high temperature specialties. *Walsh Refractories*

1185. Refractories

20-page booklet gives technical information on super refractories. *Refractories Div., Carborundum Co.*

1186. Refractories

Form 1409 on fused stabilized zirconia refractory for furnace linings, metal melting, other uses. *Norton Co.*

1187. Refractory

Reprint on Current Refractory Practice as Applied in Copper Smelting. *Harbison-Walker Refractories*

1188. Refractory Cement

Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

1189. Refractory Mixes

16-page bulletin 315 on properties and applications of sillimanite super-refractory ramming mixes and furnace patches. *Chas. Taylor Sons*

1190. Rhodium Plating

Data on properties, thicknesses required, costs, operation, applications. *Technic*

1191. Roll Formed Shapes

24-page Bulletin 1053 on designing, forming and producing shapes from ferrous and nonferrous metals. *Roll Formed Products Co.*

1192. Rust Preventive

Pamphlet on Oilcoat T for prevention of rust in lubricating systems. *Gulf Oil*

1193. Rust Preventives

12-page bulletin on water-soluble rust-preventive. *Production Specialties*

1194. Salt Bath Furnaces

Data on salt bath furnaces for batch and conveyorized work. *Upton*

1195. Salt Baths

72-page catalog, 116 B, on operating principles and use of salt baths for 26 heat treating processes. *Ajax Electric*

1196. Salt Baths

32-page booklet on heat treating in liquid salt baths. Properties of several liquid baths. *E. F. Houghton*

1197. Shearing

16-page catalog on pivoted-blade shears for cutting metal up to 1.25 in. thick. *Cleveland Crane & Engineering*

1198. Sheet Metal Testing

8-page folder on equipment for testing the drawing, stamping and folding qualities of sheet and strip. *Deakin*

1199. Shell Molding

8-page bulletin on silicones for shell molding process. *Linde Air Products*

1200. Shell Molding

28-page brochure on latest developments in shell molding. Advantages, fundamental steps, tests of methods and procedures. *Chemical Div., General Electric*

1201. Shot Peening

16-page booklet on selection and use of shot and grit for peening. *Cleveland Metal Abrasive*

1202. Silver Brazing

10-page technical bulletin on brazing preforms. Specifications for 13 types of joints. *Lucas-Milhaupt*

1203. Stainless Castings

8-page bulletin gives recommendation charts for type of stainless to use in various corrosive solutions, under various conditions. *Waukesha Foundry*

1204. Stainless Fastenings

20-page catalog of stainless steel cap screws, nuts, washers, machine screws, sheet metal screws, set screws, pipe fittings and specialties. *Star Stainless Screw*

1205. Stainless Specs

Chart of Government stainless steel specifications for fastenings. *Star Stainless Screw*

FIRST CLASS
PERMIT No. 1595
(Sec. 34.9 P.L. & R.)
Cleveland, Ohio

BUSINESS REPLY CARD

No Postage Stamp Necessary If Mailed In the United States

4c POSTAGE WILL BE PAID BY—

METAL PROGRESS

7301 Euclid Avenue

CLEVELAND 3, OHIO



Latrobe OFFERS YOU TOMORROW'S TOOL STEELS *today!*

"SELF-LUBRICATED"

XL HIGH SPEED TOOL STEELS

- DOUBLE SIX M-2 XL
- CRUSADER XL
- CORSAIR XL

"FREE MACHINING"

FM HIGH CARBON-HIGH CHROMIUM DIE STEELS

- OLYMPIC FM
- BR-4 FM
- SELECT B FM

"DESEGATIZED" HIGH ALLOY TOOL STEELS

with
Sulphide Additives
for

GREATER TOOL PERFORMANCE
IMPROVED MACHINABILITY

And They're Available from Warehouse Stock!

LATROBE STEEL COMPANY

LATROBE, PENNSYLVANIA

Branch Offices and Warehouses:

Boston Buffalo Chicago Cleveland Dayton
Detroit Hartford Los Angeles Milwaukee
Newark Philadelphia Pittsburgh
St. Louis St. Paul Toledo

Sales Agents:

Atlanta Charlotte Dallas Denver Houston
Salt Lake City Wichita

European Offices:

Geneva Brussels Paris Milan
Rotterdam Dusseldorf

send today

LATROBE STEEL CO., LATROBE, PA.

MP-2

Please send data on:

☐ XL steels ☐ FM steels

NAME _____

POSITION _____

COMPANY _____

STREET _____

CITY _____

STATE _____



Dependable Design... Economical Performance...

with

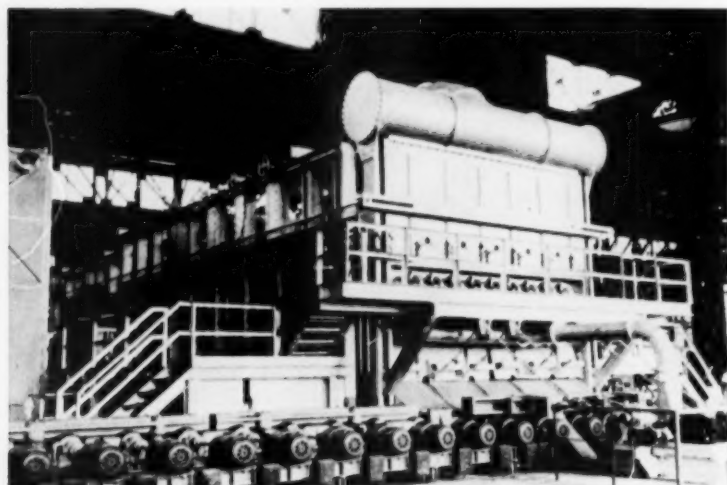
***Loftus* Continuous Heating Furnaces**

Many years of design and construction experience, coupled with practical up-to-date innovations give Loftus Continuous Furnaces dependable, trouble-free service, fitted to present day demands for lower production costs. Recognized for operating efficiency, ease of maintenance and outstanding availability; Loftus furnaces provide low-cost, quality heating, whether gas, oil, or combination fired. Large efficient recuperators of either tile, metal tube or needle type design assure maximum

heat recovery, plus ready access for maintenance.

Fully automatic fuel, pressure and temperature controls assure correct fuel-air ratio at all times with minimum fuel consumption.

Throughout the world, Loftus engineers have designed and built all kinds of continuous furnaces including many types of multizone arrangements fired from above and below the work. You can depend on Loftus design and construction to give you the best quality heating at lowest possible cost.



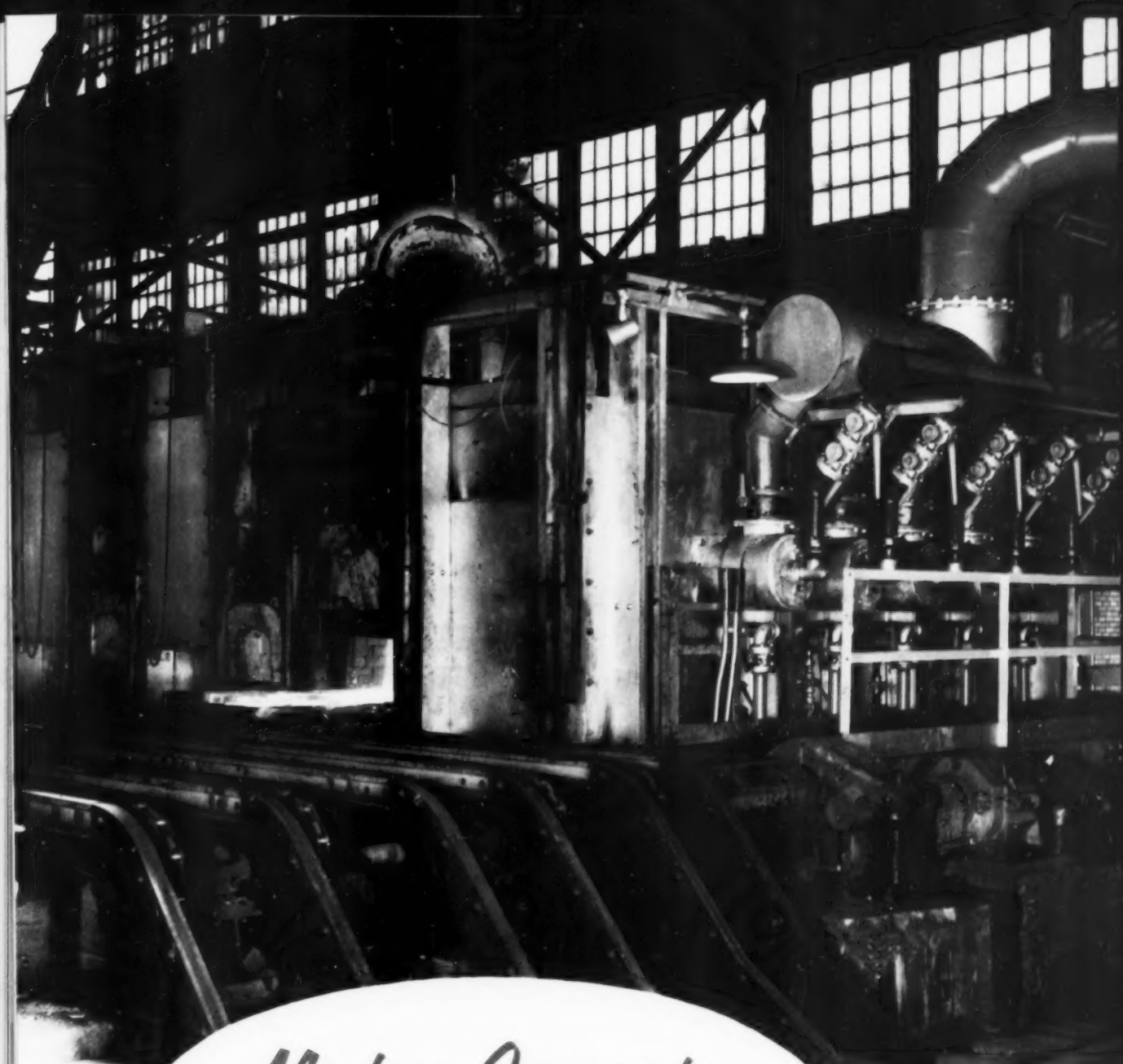
Another Loftus Continuous Heating Furnace recently installed in a Japanese Steel Plant. This furnace is used for heating steel slabs $4\frac{1}{2}' \times 24' \times 13' 6''$ to rolling temperature. Slabs are heated from cold to 2360°F . in $1\frac{1}{2}$ hours. Furnace is equipped with two zone top and bottom oil-fired burners. Two built-in recuperator cells of 5,000 square feet total heating surface preheat the combustion air. This furnace was designed to achieve the highest possible heat recovery due to excessively high fuel cost in Japan.

A consultation with Loftus engineers may pay big dividends . . .

Call or Write Today!

- Continuous Heat Treating Lines for Ferrous and Non-ferrous Metals
- Open Hearth Furnaces
- Ingot Heating Furnaces
- 60-Cycle Induction Heaters for Ferrous and Non-ferrous Metals





*Modern Concepts
in Continuous Heating*

(Courtesy of Crucible Steel Company)

Leffler

ENGINEERING CORPORATION

Designers and Builders of Industrial Furnaces

610 Smithfield Street, Pittsburgh 22, Pennsylvania

telling the story of 'dag' dispersions



How You Can Solve Hot-Lubrication Problems

Investigate the unique values of a 'dag' Colloidal Graphite *dry-film lubricant*.

'dag' dispersions are available in a choice of liquid carriers: oils, water, volatile hydrocarbons, and resin-solvent combinations. You'll find that the dry lubricating films produced by these dispersions are heat-resistant . . . much more enduring than conventional petroleum lubricants. And they keep work pieces well lubricated at all your metalworking temperatures.

Tell us your problems or write *today* for Bulletin No. 426-J7.

Dispersions of molybdenum disulfide are available in various carriers.

We are also equipped to do custom dispersing of solids in a wide variety of vehicles.

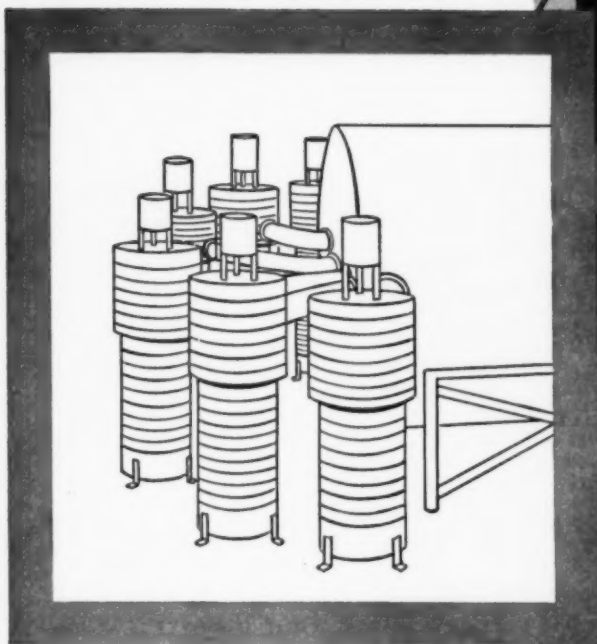


Acheson Colloids Company, Port Huron, Mich.

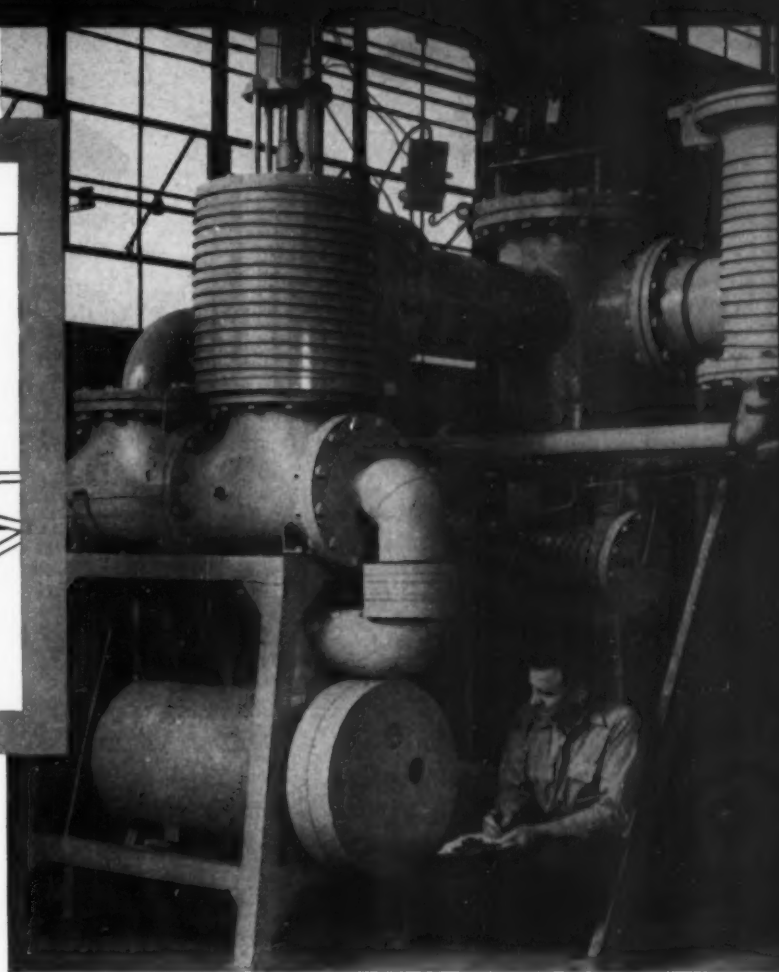
... also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND



*try 'dag' resin-bonded dry films
for permanent lubrication*



Which would you
choose for *your* high
vacuum furnace...



multiple small pumps or a single large pump combination?

The key to successful high vacuum melting and casting is **LARGE CAPACITY high vacuum pumping** in the *right* pressure range on a well designed flexible furnace.

The right range is anywhere from 300 microns (3×10^{-1} mm Hg) to 1 micron or lower absolute pressure—300 microns to take care of the inevitable burst of gas accompanying *any* melting operation—down to 1 micron or less to produce the final gas-free atmosphere so necessary to obtain high purity metals and permit adding the required alloying elements not possible at normal atmospheric pressure.

Only CVC's Ejector or Diffusion-Ejector type high vacuum pumps will remove these large amounts of gas (from .5 to 13 lbs. of air per hour) over the entire pressure range, and generally do it with a single pump or at most two pumps in series.

Before you purchase a high vacuum melting and casting furnace in any size from 50 to 2000 lbs. of melt, contact CVC's metallurgical and equipment design experts. **Consolidated Vacuum Corporation, Rochester 3, N. Y.** (a subsidiary of Consolidated Engineering Corporation, Pasadena, California).

The wide jet clearances of this CVC type KB-1500 high vacuum pump suits it particularly to use on high vacuum furnaces. Its high-speed air removal rate is 2 lbs. per hour at 50 microns. It can produce an ultimate vacuum of 5 microns Hg. operating against a forepressure of .5mm Hg. A modified version, the type KS-R800, will produce an ultimate vacuum below .1 micron and has high pumping speed at 10 to 20 microns.



Headquarters
for High Vacuum

Consolidated Vacuum Corporation

ROCHESTER 3, N.Y.

sales offices: NEW YORK, N. Y. • CHICAGO, ILL. • BOSTON, MASS. • SAN FRANCISCO, CALIF. • CAMDEN, N. J.

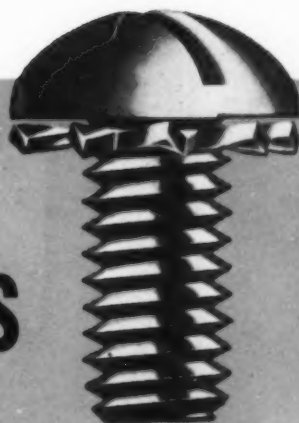


*the
problem*

*the
answer*

Mr. Emerich Bechtold, General Foreman of the Heat Treating Department, and a Gulf Sales Engineer examine the Sems as they emerge from a bath of Gulf Super-Quench.

▶ uniform hardening of SEMS



▶ Gulf Super-Quench

The Shakeproof Division of the Illinois Tool Works had a quenching problem with "Sems" — the well-known screw and lockwasher combination.

Sems are assembled — the lockwasher fitted on the screw—then heat treated. Attaining uniform hardness with conventional quenching oils was difficult, however, because of the difference in size of the heavier screw sections and the normal variations of the steel. The change to Gulf Super-Quench resulted in more uniform harden-

ing, even in the heavier sections, without any cracking of the lockwashers.

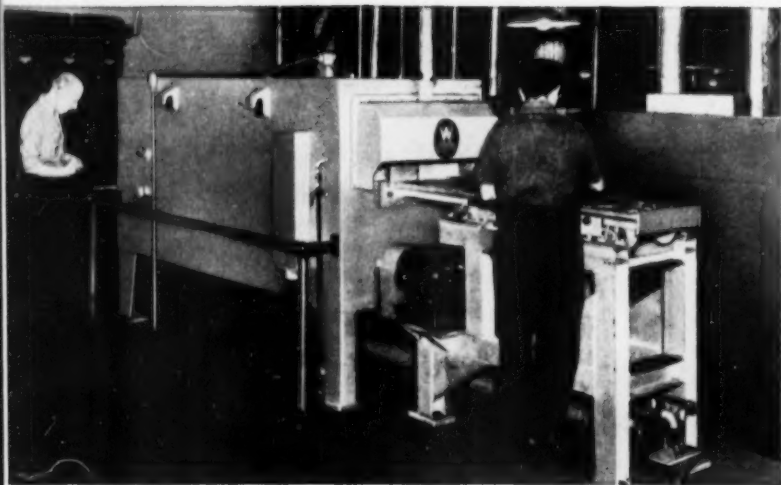
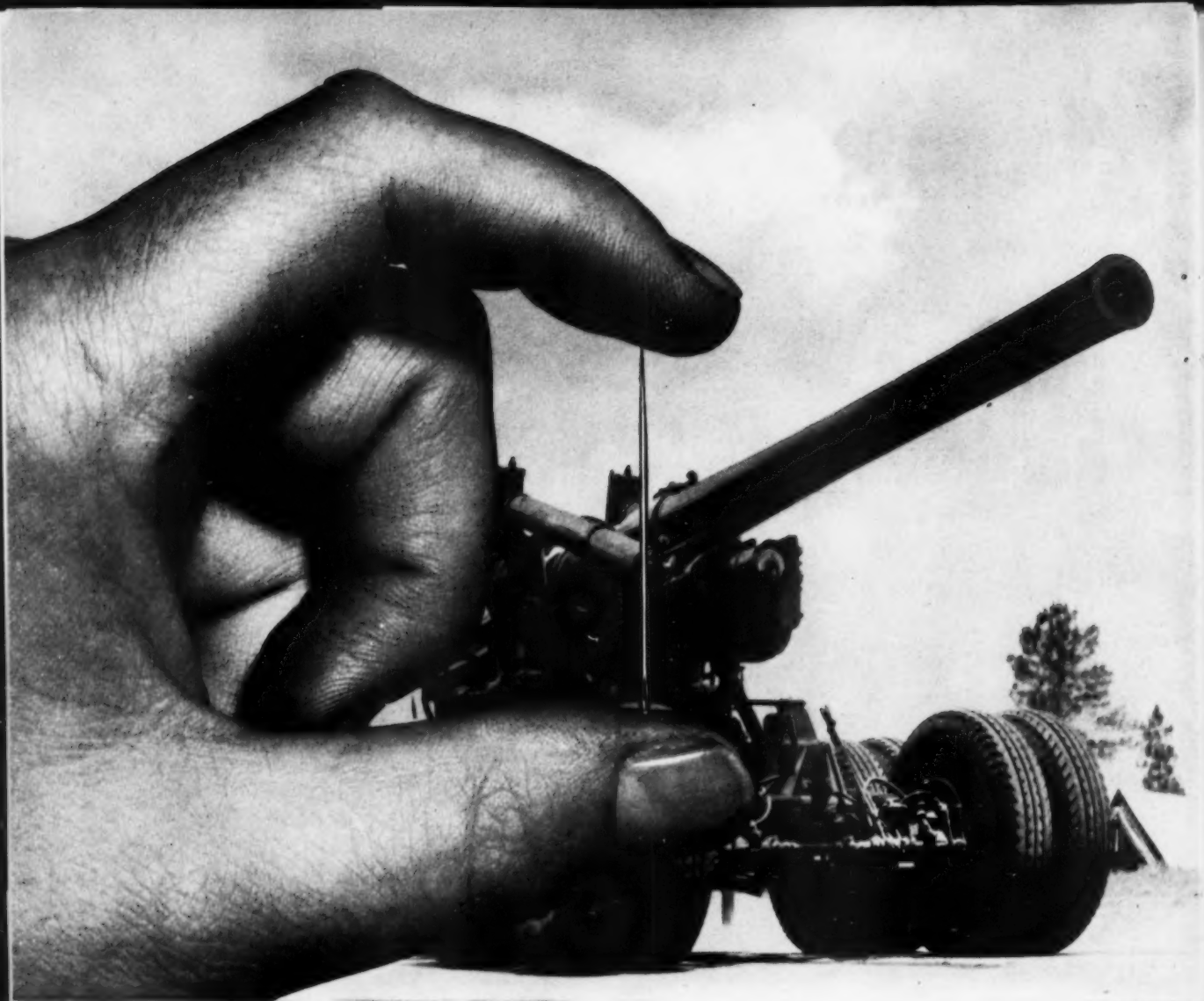
Just another example of Gulf Super-Quench's ability to get faster quenching without cracking and distortion, maintain uniform hardness, and cut rejects on many different types of steel parts.

Have a Gulf Sales Engineer help you discover opportunities to put Gulf Super-Quench to work—profitably—in your shop. Contact your nearest Gulf office today and have him call.

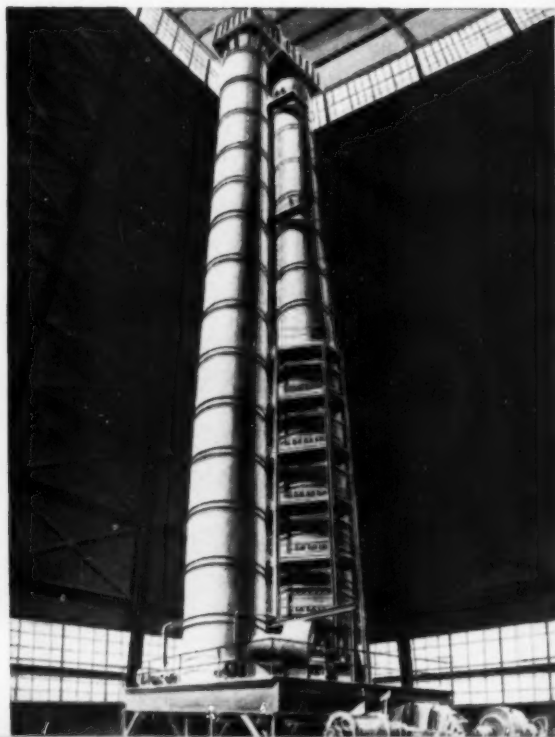
Gulf Oil Corporation • Gulf Refining Company

1822 Gulf Building, Pittsburgh 30, Pa.





FROM BOX TYPE TO ELEVATOR TYPE . . . this wide range of Westinghouse furnaces offers industry heat-treating units specially engineered for the smallest toolroom jobs on up to furnace capacities for massive parts treating. Accurate temperature control, uniform temperature distribution and low heat loss in Westinghouse furnaces assure high and constant quality level.



Needles to cannon barrels...

heat-treat them

in Westinghouse furnaces

Across the board in heat-treating, for small jobs or mass production, Westinghouse makes the exact furnace needed. From manually operated box type to complex automatic conveyor units, Westinghouse furnaces assure the maximum in speed, quality and economy.

This complete line includes furnaces using either gas or electric heat source . . . atmosphere generators providing all gas variations required . . . and auxiliary equipment to speed and simplify work handling.

Specialized Engineers and Facilities Work for You

Westinghouse offers a unique and comprehensive service that extends ideas, know-how and

capacity to solve heat-treating problems. At any stage of planning or production, Westinghouse engineers can be called to your plant for sound, unbiased recommendations that will help you get more from heat-treating operations. Skilled designers, packaged installation techniques (even to complete erection and installation where needed) and maintenance follow-through, combine with this engineering staff to form a dependable service that is unmatched in the heat-treating field.

Use coupon below for your free 40-page book on the complete line of Westinghouse furnaces and equipment. For further information write Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-10433

YOU CAN BE **SURE**...IF IT'S

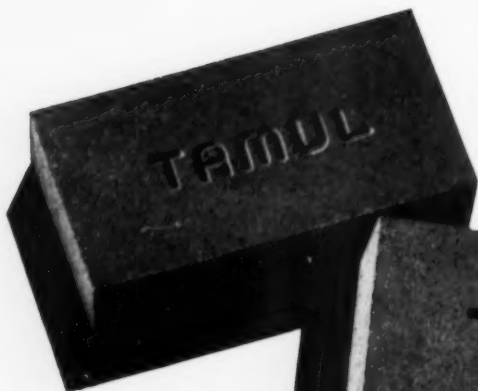
Westinghouse



Westinghouse Electric Corporation
3 Gateway Center, P. O. Box 868, Pittsburgh 30, Pennsylvania
Please send free copy of B-5459 to:

Name _____ Title _____
Company _____
Address _____
City _____ State _____

CHAS. TAYLOR *presents*



Base: Sintered synthetic mullite
P.C.E.: Cone 39 (3389°F.)
Al₂O₃ Content: 67-69%
Available as: Brick, special shapes



Base: Highest quality, premium grade
Indian kyanite
P.C.E.: Cone 37-38 (3308-3335°F.)
Al₂O₃ Content: 57-60%
Available as: Brick, special shapes,
specialties



Base: Highest quality, premium grade Indian kyanite
fortified with alumina.
P.C.E.: Cone 38-39 (3335-3389°F.)
Al₂O₃ Content: 66-68%
Available as: Brick, special shapes



Base: Sintered Corundum
P.C.E.: Cone 41 (3578°F.)
Al₂O₃ Content: 88-90%
Available as: Brick, special shapes, specialties



Base: Purest commercial grade zirconium silicate
P.C.E.: Above Cone 42 (above 3659°F.)
Available as: Brick, special shapes, specialties



Additional data on these brands with recommendations on
applications will be gladly supplied on request. Contact
your Taylor field engineer or write us direct.

CHAS. TAYLOR SONS Co.
A SUBSIDIARY OF NATIONAL LEAD COMPANY

REFRACTORIES SINCE 1864 • CINCINNATI • OHIO • U.S.A.



Sixty *OK's* keep TIMKEN® stainless steel forging bars uniform

THE test pictured above is only one of the sixty chemical tests every heat of Timken® stainless steel must pass. With all these checks for chemical composition, we can be sure that an analysis is *right*. That's why you can be confident that every bar in every order of Timken stainless steel forging bars is uniform in physical and chemical properties. Forgeability and response to heat treatment are uniform, too, so it isn't necessary to change shop practices with every shipment of material. Production time is saved, scrap

loss is cut and you get a high quality finished product.

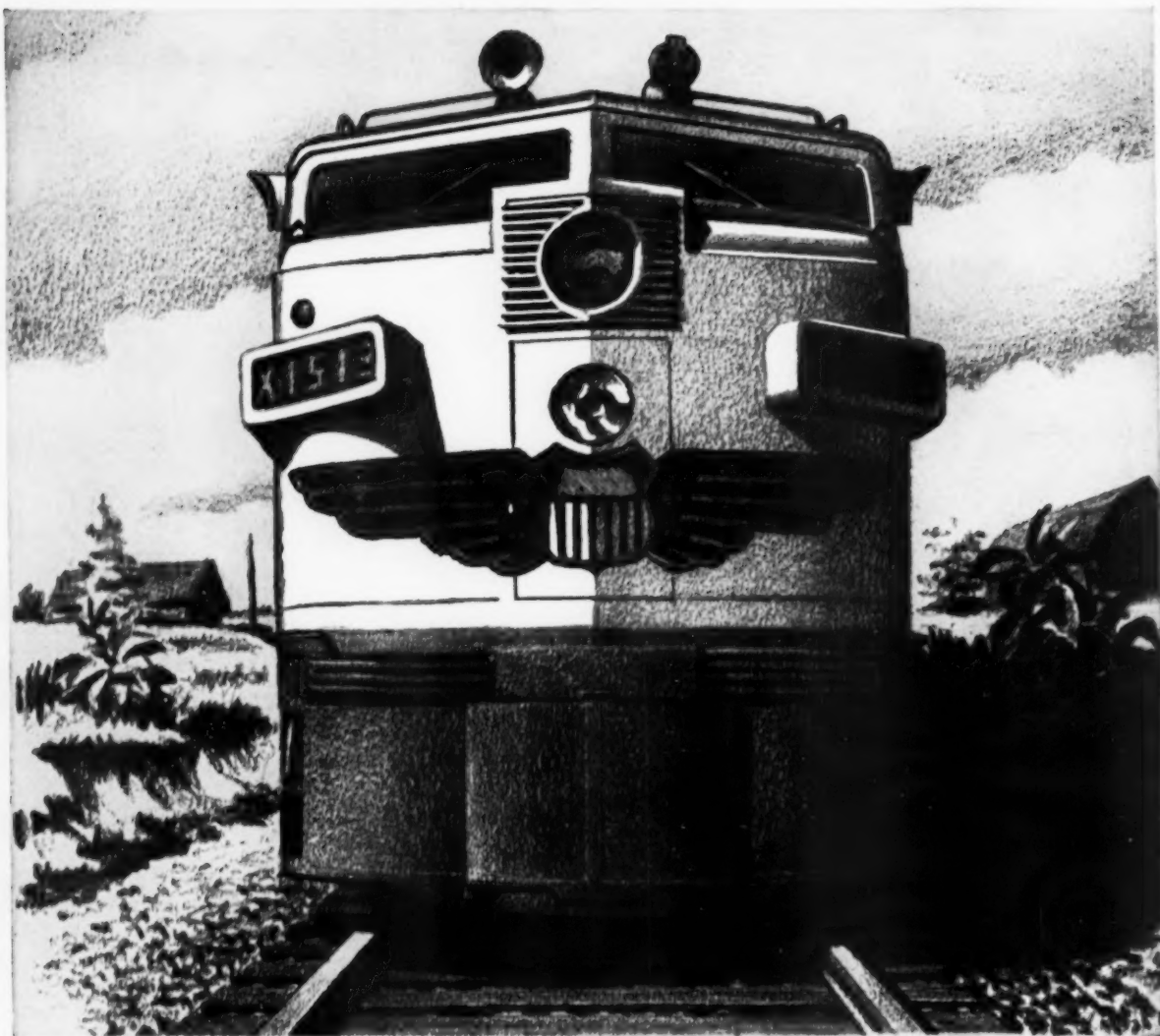
Call on our technical staff to help you choose the correct analysis of Timken stainless steel forging bars. And rely on our production department to get it to you when you want it. Want to know more about Timken stainless steel forging bars? Write for our technical bulletins. They're free, of course. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH



SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

SEPTEMBER 1954; PAGE 43



Here's where heat and corrosion prove metal...and metallurgists

**For castings subject
to High Fluctuating
Temperatures . . .**

**Waukesha No. 321
Titanium Stabilized
Stainless Steel**

Supercharger inlet ports in giant rail-road diesels demand castings of unusual characteristics. They must be high in corrosion resistance, and must maintain this resistance under abnormally high temperature fluctuations. In addition, close tolerances demand easy machinability.

This is the kind of problem that naturally comes to Waukesha Metallurgists for laboratory solution. Waukesha No. 321 Stainless Steel with *titanium*, with carefully controlled modifications, offered a solution. Its effective use in castings requires a high degree of knowledge and skill both in formulation and in

production, but Waukesha has succeeded in casting it for such critical uses as trays and conveyor parts for heat treating furnaces and other high temperature needs. Its adaption to G-E Supercharger inlet ports is another example of Waukesha's experience in serving industry with the more difficult alloys.

Have You a Castings Problem?

Take this opportunity to prove Waukesha's advanced metallurgical service — to your profit! Send us a pattern for sample casting. Or write for booklets containing current data on Waukesha Stainless Steel and "Waukesha Metal".

call *Waukesha*
first . . .

WAUKESHA FOUNDRY CO.

5404 LINCOLN AVE., WAUKESHA, WISCONSIN

For Metallurgical Aid in Every Corrosion Resistant Alloy



Get the "PACKAGE"

when you buy HEAT TREATING SALTS!

Houghton's research staff works closely with metalworking plants—often side by side with your heat treaters—in servicing salt baths.

So valuable ingredients that are not in the formula go with every Houghton Salt you buy—wide knowledge of your heat treating problems and on-the-job service that helps you solve them!

Houghton Liquid Salt Baths cover a temperature range of 350° F. to 2400° F.—for tempering, martempering, annealing, quenching, carburizing, nitriding, normalizing and hardening of ferrous and non-ferrous metals.



Ask the Houghton Man for help he'll gladly give you—or get for you—to assure fast, uniform metal treatment batch after batch. Or write to E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa., for latest "Liquid Salt Baths" book.

LIQUID SALT BATHS

... products of

E. F. HOUGHTON & CO.
PHILADELPHIA • CHICAGO • DETROIT • SAN FRANCISCO

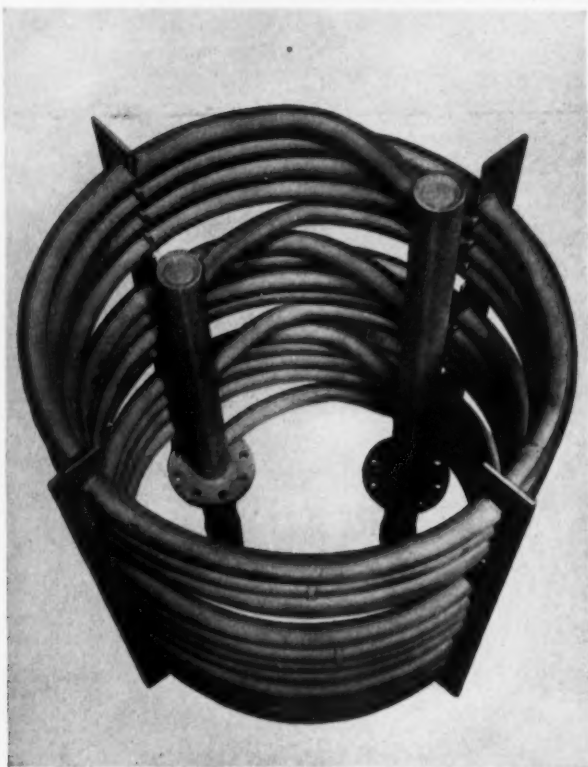


Ready to give you
on-the-job service . . .



• Cross section of Duplex Tubing, lead outside, copper inside.

Courtesy: The Bridgeport Brass Co., Bridgeport, Conn.



• Lead-copper Duplex Tubing cooling and heating coil.

Courtesy: The Patterson-Kelley Co., Inc., East Stroudsburg, Pa.

• A job for CHEMICAL LEAD and the CHEMICAL LEAD for the job!



It would be difficult to think of any product in modern life which — somewhere along the line of manufacture — has not been in contact with sulfuric acid. Indeed, the volume of H_2SO_4 produced annually is sometimes called a standard for measuring the "civilization" of a nation. In the United States alone, nearly eleven million tons of 100% sulfuric acid have been produced and consumed in a single year.

Lead is a virtually indispensable material of construction in our vast chemical industries. For lead has the unique property of forming automatically upon its surface a protective coating of insoluble and tightly adherent lead salts which makes the metal practically immune to the attack of H_2SO_4 . In addition to its unmatched durability, versatile lead — with its low melting point, softness, pliability — is easy to fabricate. Rolled in sheets, lead is readily formed into linings for

tanks and all manner of vessels for the handling of acids. Extruded in tubular form, or cast in molds or dies, lead makes pipe, coils and innumerable other items for use with corrosive liquids.

Lead's durability is frequently utilized in combination with other metals when product-application calls for properties not inherent in lead — such as strength for instance. The steam heating and cooling coil shown above is a typical example. While coils for immersion in sulfuric acid solutions are generally made of lead, operating conditions, such as extreme heat and pressure, sometimes make it necessary to use two metals for the tubing — in this case, lead outside for its corrosion resistance and copper inside to provide higher strength.

St. Joe Chemical Lead — an exclusive product of the huge ore bodies of Southeast Missouri which have been owned and operated by this Company since 1865 — has been and is now, the most extensively used brand of lead in the chemical industries, and hundreds of thousands of tons are now in use. Last but by no means least, when the life of the equipment is spent, the metal is easily reclaimed and, due to the imperishable nature of lead, is returned to the market for another cycle of long and useful service.

ST. JOSEPH LEAD COMPANY

250 PARK AVENUE ELIZABETH 5, N. J. 07208 NEW YORK 17
THE LARGEST PRODUCER OF LEAD IN THE UNITED STATES



Attend...

THE 1954 IRON and STEEL EXPOSITION

**CLEVELAND PUBLIC AUDITORIUM, Cleveland, O.
SEPTEMBER 28, 29, 30 and OCTOBER 1**

Learn...

Whether your interests are design, construction, operation or maintenance—your job requires that you *see* the latest equipment, supplies and services displayed by over 200 companies—and *hear* papers presented at the technical sessions on every phase of steel production by the industry's most outstanding authorities.

Benefit...

The benefits derived from viewing the displays, hearing the technical sessions, and the individual discussions you will have with men whose problems are similar to your own, will more than compensate for your time. Don't miss it. Join the more than 15,000 men who will attend—who know from past experience the value of this great Exposition.

REGISTRATION IS FREE!

ASSOCIATION OF



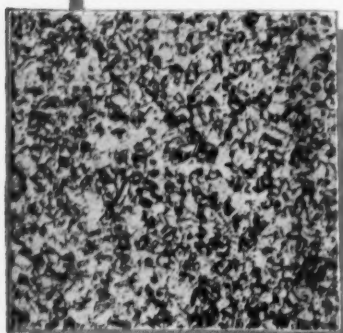
IRON and STEEL ENGINEERS

1010 EMPIRE BUILDING, PITTSBURGH 22, PENNSYLVANIA

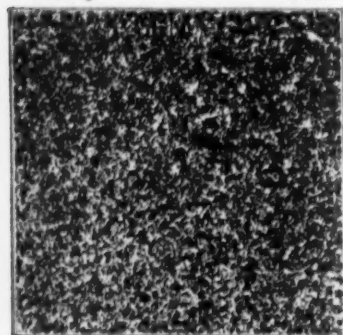
Which Grain Size For Deep Drawing Brass?

by R. C. LeMay

Selas Corporation of America



Coarse—Grain size 0.020 mm obtained with conventional batch annealing. 75X



Fine—Grain size 0.010 mm max. obtained by high speed continuous annealing. 75X

Industry has for many years recognized the dependence of mechanical properties, as well as workability, upon grain size variations in brass. It is the accepted theory that with increasing grain size, tensile strength decreases and the per cent elongation increases. On this basis, it is usual practice to specify a coarser grain for deep drawing brass to provide the necessary degree of ductility.

The objectionable feature of a coarse grain for finishing work is the development of a rough "orange-peel" surface, which is difficult to buff. Conventionally processed brass for deep draws aims at a compromise between coarse grain for ductility and fine grain for improved surface.

The grain sizes shown above are representative for 85-15 red brass strip currently supplied the "eyelet" trade for deep drawn articles, such as lipstick containers and fountain pen caps, where high ductility and ease of buffing are prime requirements. The coarser grain is typical of material processed by batch annealing, in coils, on long time cycles involving many hours.

The fine grain is from material processed by a new, continuous method at the Somers Brass Company in Waterbury, Connecticut. In this operation a single strand of brass strip, moving at speeds up to 190 feet per minute, is heated to annealing temperature in but seconds and is then quickly cooled. The fine grain shown above is smaller than the minimum size (0.015 mm) appearing in the ASTM Standard Micrographs for Comparison of Grain Sizes.

A comparison of the mechanical properties for the two materials follows:

	Fine Grain	Coarse Grain
Annealing method	Continuous	Batch
Grain size, mm.	0.010 max.	.020
Tensile strength, psi	47500	44000
Elongation, %	40	40

(Data furnished by Somers Brass Co.)

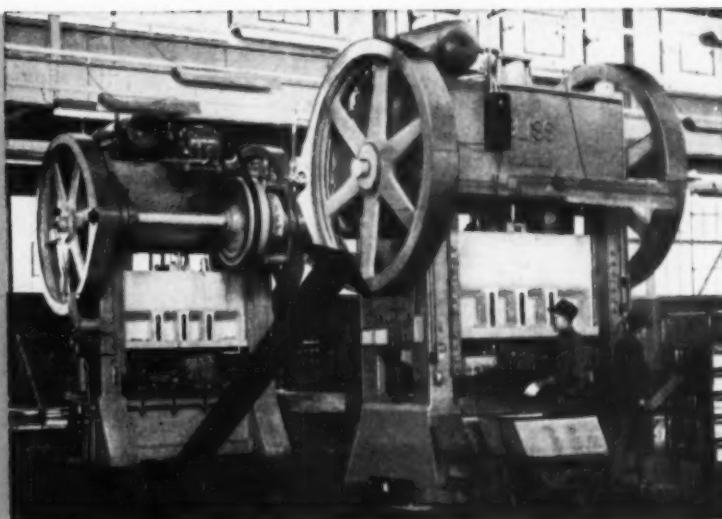
The dual objectives of (1) fine grain for less buffing and (2) ample ductility for deep drawing, cannot be realized by conventional annealing practices, and, therefore, require a compromise between the two conditions. The development of a very fine grain by coil annealing requires prolonged holding periods at low temperatures, which does not assure complete recrystallization. The presence of a small amount of unrecrystallized metal limits the maximum ductility obtainable.

High speed annealing by the continuous method produces complete recrystallization at a high temperature and permits quick cooling to prevent grain coarsening by coalescence. This harder, more scratch-resistant, more ductile material, which requires only a simple color buff after draw, is superior to any other brass available for deep drawing buffed products.

The continuous process has been made possible through use of a Selas direct gas-fired furnace, requiring no costly, externally-prepared atmospheres to produce a uniform, clean annealed strip. The process, with heating times under ten seconds, is the fastest in the brass industry today. The furnace requires less floor space than other types of continuous strip annealers. Other advantages include low maintenance costs, reduced amount of material in process and operational flexibility for handling rush orders.

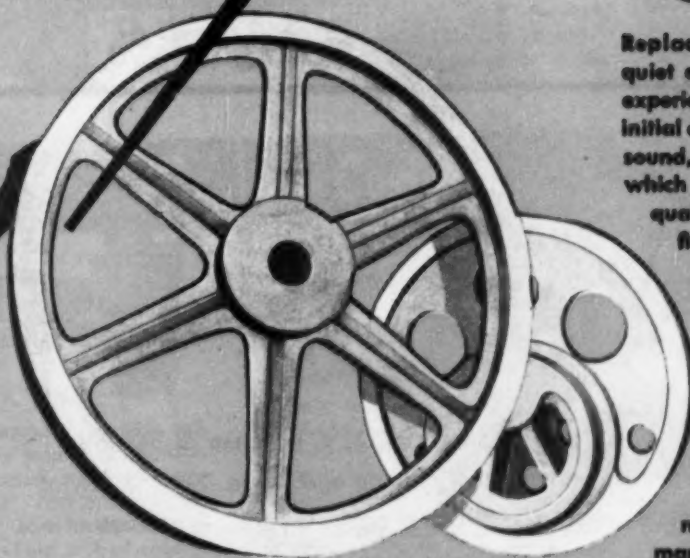
Selas Corporation of America
Philadelphia 34, Penna.

Improve
quality
and
cut costs
with



DUCTILE CAST IRON

Gears



Replace Cast Steel Gears with quiet operating Ductile Iron and experience longer life with lower initial cost. Ductile Iron is a dense, sound, free machining material which possesses all the desirable qualities of the best grades of flake graphite Cast Iron and strength characteristics approaching that of Cast Steel. The Youngstown Foundry & Machine Company has done extensive experimental work during the last four years and is now casting the ideal engineering material for the manufacture and maintenance of Presses. Let us have your inquiries and we will show you how we can improve the quality and cut the cost of your Gears.

5,000 lb. and 3,000 lb. Gears have amazing properties

TYPICAL TEST RESULTS

AS CAST

95,000 PSI Tensile Strength
70,000 PSI Yield Strength
4-8 % Elongation

ANNEALED

70,000 PSI Tensile Strength
55,000 PSI Yield Strength
15 % Elongation

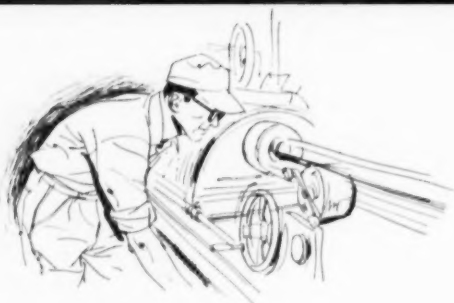
The Youngstown Foundry & Machine Co.



Youngstown, Ohio

**Machine
Bearing
Rejects
WERE
42% ... NOW**

only 5%



A machine tool manufacturer had 42% rejection of bearing races at final inspection, after two regrinding operations. Substitution of vacuum-melted steel reduced this loss to less than 5%. Properties of vacuum-melted metals include: greater impact and fatigue strength . . . better machinability . . . cleaner, higher polished surfaces. We can deliver commercial quantities. Write for more facts.

**These
Vacuum-Melted Metals
Now Available**

FERROVAC® 52100 and 51100

FERROVAC® 4340

HIGH ALLOY STEELS



**VACUUM
METALS
CORPORATION**

P. O. BOX 977, SYRACUSE 1, NEW YORK

Jointly owned by Crucible Steel Company of America and National Research Corp.

Better Brazing

that actually costs less!

Saves \$25,000 ANNUALLY!



SAE-1010 steel bicycle forks are brass brazed at the rate of 280 forks per hour in a mechanized Ajax salt bath unit that brazes, washes and dries the forks automatically. Production has been increased 270%.

THE BRAZING IS PRACTICALLY Free!

Brazing and carburizing of this SAE-1010 steel sprocket assembly are completed simultaneously with one heating of the work in an Ajax salt bath carburizing furnace. Hub is brass-brazed to sprocket body . . . The assembly is file hard after oil quenching.



Tolerances OF 0.002" EASILY HELD!



Micro-wave components, like this aluminum wave guide, can be aluminum dip-brazed, holding tolerances of 0.002". Fast brazing time and uniform bath temperatures (guaranteed within 5°F of control point) give high production and uniform results.

LABOR Costs Cut 96%!

Copper heat exchangers are silver brazed in only 1 1/4 minutes in a 1500°F bath. Return bends on each end are brazed simply by immersing only that portion of the assembly. Former hand torch brazing required 30 minutes.



Any material that can be brazed at all can be brazed in an Ajax Electric Salt Bath Furnace — *much faster, better and usually at lower cost.* First cost of equipment is only 1/2 to 1/3 that of any other production brazing system. But that's only part of the story:

Brass Brazing of Steel Parts — Brass brazed joints are fully as strong as those of copper! This money-saving method is possible only with a salt bath furnace, thanks to its greater heating speed — so fast that no de-zincification of the brazing metal occurs. Brass brazing at 1700°F compares with 2050°F for copper. The lower temperature greatly reduces grain growth and distortion of the steel. Operating costs are less.

Brazing of Other Metals — Brazing aluminum, brass, copper and bronze assemblies is quick and inexpensive because of the Ajax furnace's rapid heating rate — 4 to 6 times faster than atmosphere type furnaces. Any suitable brazing metal can be used. Temperatures controlled within 5°F minimize distortion. Selective heating is easy. Scaling and decarburization are avoided.

Simultaneous operations possible — Where a brass brazed assembly must also be carburized or hardened, the entire job can be done in a single heating operation at 1700°F. The brazing is practically free!

Write for . . . Bulletin 124, also list of documented brazing case histories covering a wide variety of industries.

Send . . . Your sample parts to the Ajax Metallurgical Service Laboratory for processing. No cost or obligation.



AJAX
MULTIGREN

electric SALT BATH furnaces

World's largest manufacturer of electric heat-treating furnaces exclusively

AJAX ELECTRIC COMPANY, 910 Frankford Ave., Philadelphia 23, Pa.

Associated Companies: Ajax Electric Furnace Corp. • Ajax Electrothermic Corp. • Ajax Engineering Corp.

Save 5 ways with pallet boxed shipments



FERROCHROMIUM, FERROSILICON, FERROMANGANESE BRIQUETTES



Now—

You can save time and money through...

- 1. EASIER HANDLING**—Pallet boxes for Vancoram Briquettes and ferro alloys have been especially designed for safe, easy handling. Constructed of sturdy hard wood and tied with strong steel strapping—the chance of breakage is minimized.
- 2. MORE EFFICIENT STORAGE**—The design and strength of Vancoram Pallet boxes permit safe multiple stacking indoors or out, which may not be feasible with more flimsy construction.
- 3. READY IDENTIFICATION**—Pallet boxes of Vancoram Briquettes and ferro alloys are easily identified by the same plain marking and color-coding identification labels used on Vancoram Drums.
- 4. LESS CHANCE OF CONTAMINATION**—Material confined to its own container rather than unwieldy bulk handling.
- 5. FASTER INVENTORY**—Has the advantages of packed shipment in easy, quick inventory.

Besides briquettes, most other Vancoram ferro alloys are available in economical, easily-handled pallet boxes — another Vancoram service to you.

Producers of alloys  metals and chemicals

VANADIUM CORPORATION OF AMERICA

420 Lexington Avenue, New York 17, N. Y.

Detroit • Chicago • Pittsburgh • Cleveland

Superior

TYPE 430

STAINLESS STEEL

The Heart of the Lighter

FOR HEAT RESISTANCE
RESISTANCE TO CORROSION
EASE OF FABRICATION
UNIFORM HIGH QUALITY

This famous lighter has a stainless heart that never fails in service 'round the world. It's because it is made of stainless 430 Stainless, the lighter body never rusts, always withstands readily for filing, is unaffected by heat or flame—most fabricators preferably in the first place. We can supply your stainless needs with Type 430 in specified dimensions and finishes. Send us your inquiry.

Superior Steel

CORPORATION

CARNEGIE, PENNSYLVANIA

AMAZING POLISHING DISCOVERY!



MICROCUT

A NEW BUEHLER POLISHING PAPER MAKES SAMPLE PREPARATION EASIER

Another Aid To The Metallographer

This paper combines the advantages of extremely fine grit size, rapid and clean cutting, long life, wet or dry operation. Use in place of 3/0 Emery Polishing Paper to produce better samples in less time.

ASK FOR A FREE SAMPLE

No. 1413-SW AB MICRO CUT POLISHING PAPER DISCS, 8" diameter, wet or dry, grit 600 soft, per hundred \$16.00

No. 1433-SW AB MICRO CUT POLISHING PAPER DISCS, 8" dia. with 1/2" hole, wet or dry, grit 600 soft, per hundred \$16.00

No. 1434-SW AB MICRO CUT POLISHING PAPER SHEETS, 9" x 11", wet or dry, grit 600 soft, per hundred \$20.00

No. 1435-SW AB MICRO CUT POLISHING PAPER ROLL, 4" x 150", wet or dry, grit 600 soft, per roll \$15.00

Buehler Ltd.

METALLURGICAL APPARATUS

2120 GREENWOOD STREET, EVANSTON, ILLINOIS, U.S.A.



*Metal
Progress*

BULLETIN BOARD

THE BUYERS GUIDE FOR METALS ENGINEERS



NARACO

Method of Rodding

FINISHING TIPS

Chrome finishing for decorative hood ornaments—such as the "Rocket"—shown on this car is a plating problem . . . even to the experienced plater. NARACO'S know-how in engineering has answered this problem! They have designed an efficient rack, with accurately spaced rubber bars, which produces a uniform chrome deposit free from any shading or burning. You too can take a timely finishing tip from NARACO. Plating Rack and Fixture Service by calling your nearest NARACO Plant—today!

NARACO

NATIONAL RACK CO. INC. 179-181 Madison Street Paterson, New Jersey	IMPERIAL RACK CO. INC. 1109 E. Stewart Avenue Flint, Mich.	AMERICAN RACK CO. 703 W. Root Street Chicago, Ill.	INDUSTRIAL RACK CO. 3442 N. San Fernando Road Los Angeles, 69, Cal.
--	--	--	---

LIST NO. 14 ON INFO-COUPON PAGE 64



"Pur-Blac"

- Economical
- No Change in Dimension
- Corrosion Resistant
- Perfect Uniformity
- Non-Technical

The Black Oxide Finish That
Penetrates Iron & Steel Surfaces

**PURITAN MANUFACTURING CO.
WATERBURY, CONN.**

LIST NO. 95 ON INFO-COUPON PAGE 64

RUST-LICK

IN
AQUEOUS SYSTEMS

Grade "C-W-25"

Non-flammable

Non-toxic

Aqueous Oily Film

Protects Ferrous Parts


for Long Periods

Indoor Storage

Write for free sample and brochure
Specify Grade "C-W-25"

PRODUCTION SPECIALTIES, INC.
755 BOYLSTON STREET
BOSTON 16, MASS.

LIST NO. 121 ON INFO-COUPON PAGE 64



20th Century

*the
persuasive
abrasive*

Whether your concern is castings, forgings or metal parts, make 20th Century *Normalized shot and grit a part of your straight-line production operation.

The high uniformity and greater durability of 20th Century *Normalized give you maximum efficiency, increased economy, and a quality product.

New catalog No. 1153 on request.

THE CLEVELAND  **CO.**

836 East 67th Street • Cleveland 8, Ohio
Howell Works: Howell, Michigan

One of the world's largest producers of
quality shot, grit and powder—Hard
Iron—Malleable (*Normalized)—Cut
Wire—Cast Steel (Realsteel)
*Copyrighted trade name

LIST NO. 2 ON INFO-COUPON PAGE 64



MANHATTAN

**Abrasive Wheels — Cut-off Wheels
Finishing Wheels—Diamond Wheels**

Custom-made for your specific
material removal problems

**Foundry Snagging—Billet
Surfacing—Centerless Grinding**

Cutting and Surfacing concrete,
granite, and marble

"Meldiscs" for rotary sanders

Grinding and Finishing
stainless steel welds

**Bearing Race Grinding
and Finishing**

Finishing Tools and Cutlery

**Cutting-off—Wet or Dry Bars, Tub-
ing, Structural, etc. Foundry Cutting**
—standard and reinforced wheels

Grinding Carbide Tipped Tools

Write to Abrasive Wheel Department

Raybestos-Manhattan, Inc.
MANHATTAN RUBBER DIVISION
92 TOWNSEND ST. • PASSAIC N. J.

LIST NO. 1 ON INFO-COUPON PAGE 64

Do you know the **TECHNIC METHOD**
of Electroplating

RHODIUM?



TECHNIC INC.

Providence, Rhode Island, U. S. A.

Jackson 1-4200

THE LARGEST ENTERPRISE OF ITS KIND IN THE WORLD

LIST NO. 116 ON INFO-COUPON PAGE 64

**HOW TO DO
BRIGHT GOLD
PLATING**
*without scratch
brushing or
buffing!*

**GOLD
SILVER
RHODIUM**

Write for complete details

LIST NO. 108 ON INFO-COUPON PAGE 64



BRIGHT GOLD PROCESS

**FOR INDUSTRIAL and
DECORATIVE USES**

1. Exceptionally hard deposits — twice the hardness of conventional gold plating.
2. Operates at room temperature — requires absolute minimum control.
3. Excellent metal distribution and "throwing power."

SEL-REX PRECIOUS METALS, INC.

Dept. 88, 229 Main Street
Belleville 9, N. J.

WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

- Hairpin Hooks • Sheet Crates
- Steam Jets • Chain
- Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.

3721 OAKWOOD AVE. YOUNGSTOWN, OHIO

LIST NO. 94 ON INFO-COUPON PAGE 64

METAL PROGRESS; PAGE 54

RUST-LICK

IN
AQUEOUS SYSTEMS

Grade "B"

**FERROUS
METAL PROCESSING**

Eliminates . . .

*Rust
Fire Hazards
Toxicity
Dermatitis
Degreasing*

Write for free sample and brochure
Specify Grade "B"

PRODUCTION SPECIALTIES, INC.

755 BOYLSTON STREET
BOSTON 16, MASS.

LIST NO. 105 ON INFO-COUPON PAGE 64

**Avoid Plating Rejects by
Getting Clean Metal Surfaces With
PROMAT ACID ADDITIVE**



Promat acid additive is actually an accelerator—not an inhibitor. It assures complete and uniform removal of hot rolled or heat treated scale—rust—oxide film.

TRY a one-gallon can of #7073 in your shop—**DISCOVER** the time-saving, money-making advantages now!

Special Trial
Offer
\$5.00
Postpaid

Send today for bulletins on the complete Swift line of metal finishing and treating compounds.

Swift
INDUSTRIAL
Canton

CHEMICAL CO.
Connecticut

LIST NO. 92 ON INFO COUPON PAGE 64

**Plan to Attend
the
METAL
SHOW**

**Chicago
November 1 to 5
1954**

BASKETS

for de-greasing — pickling
anodizing — plating
materials handling
small-parts storage

of any size and shape —
any ductile metal

by
THE C. O.

JELLIFF

LIST NO. 91 ON INFO-COUPON PAGE 64

**today's
wonder drug
for industry**

*NOW... the greatest
cost-saving, labor-
saving, FINISHING
DEVELOPMENT in
a decade!*

Make expensive time-consuming operations like filing, grinding, polishing, blasting, buffing a thing of the past with New Amazing SUPERSHEEN SPEED FINISHING.

It absolutely does away with costly hand deburring and other hand operations requiring the use of large quantities of expensive materials and costly skilled labor.

A single unit replaces from 2 to 12 men. Savings up to 95% on almost ALL types of parts with absolute uniformity, fewer rejects, finer finishes.

Investigate today!



Write for NEW
FREE, 32-page
Catalog

Write the
address
any with street, city,
state and nation and
your return.

DEPT. J-7

ALMCO Supersheen

AMERICA'S LARGEST MANUFACTURER OF ADVANCED BARREL
FINISHING EQUIPMENT - MATERIALS AND COMPOUNDS
ALBERT LEA, MINNESOTA

LIST NO. 75 ON INFO-COUPON PAGE 64

for all
industrial
requirements



MFG. CORP.

**28 Pequot Road
Southport, Conn.**

**On any steel blackening problem
DEPEND on DU-LITE
for a Superior Finish**

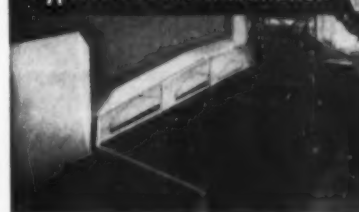
Here's an
example...



Courtesy The Poly Choke Co.

Du-Lite gave this part with its complicated knurls, slots, threads, etc. a fine rust-resistant durable black finish. It is typical of many other parts, small and large, which have been black oxidized by Du-Lite for many years. Moreover, Du-Lite meets most individual and government specifications including 57-0-2C for Type III Black Oxide finish.

Typical Du-Lite installation



Du-Lite installations are simple, compact, easy to operate. Du-Lite equipment can be tailored to fit production requirements on all types of jobs with a maximum of speed and economy. Du-Lite also makes a complete line of cleaners, strippers, wetting agents, passivating agents, rust preventatives, burnishing compounds etc. for any metal finishing application.

See your nearest Du-Lite Field Engineer
or write for more information.

DU-LITE CHEMICAL CORP.
MIDDLETOWN, CONN.

Rush information on your metal
finishing products.

Name _____
Company _____
Address _____
City _____ Zone _____ State _____

Du-Lite

METAL FINISHING SPECIALISTS

LIST NO. 103 ON INFO-COUPON PAGE 64

METAL PROGRESS, PAGE 55

**Inspection
Demagnetizing
or Sorting
PROBLEMS?
SOLVED with**

**MAGNETIC ANALYSIS
MULTI-METHOD EQUIPMENT**

Electronic Equipment for non-destructive production inspection of steel bars, wire rod, and tubing for mechanical faults, variations in composition and physical properties. Average inspection speed 120 ft. per minute.

Over 50 steel mills and fabricators are now using this equipment.

**MAGNETIC ANALYSIS
DEMAGNETIZERS**

Electrical Equipment for rapid and efficient demagnetizing of steel bars and tubing. When used with Magnetic Analysis Multi-Method Equipment, inspection and demagnetizing can be done in a single operation.

**MAGNETIC ANALYSIS
COMPARATORS AND METAL TESTERS**

Electronic Instruments for production sorting both ferrous and non-ferrous materials and parts for variation in composition, structure and thickness of sheet and plating.

**MAGNETIC ANALYSIS
MAGNETISM DETECTORS**

Inexpensive pocket meters for indicating residual magnetism in ferrous materials and parts.

For Details Write: "THE TEST TELLS"

MAGNETIC ANALYSIS CORP.

42-44 Twelfth St., Long Island City 1, N. Y.

LIST NO. 51 ON INFO-COUPON PAGE 64

**Alexander
SHEET METAL TESTER
For Erichsen Test**

Determines workability of ferrous, non-ferrous and fine metal sheets and strips to point of fracture. Reading—accurate to 0.0004" . . .



Write for Catalog

J. ARTHUR DEAKIN & SON

150-28 Hillside Ave. • Jamaica 32, N. Y.

LIST NO. 89 ON INFO-COUPON PAGE 64



If you want to perform
Tensile or Brinell testing operations
quickly and simply—contact

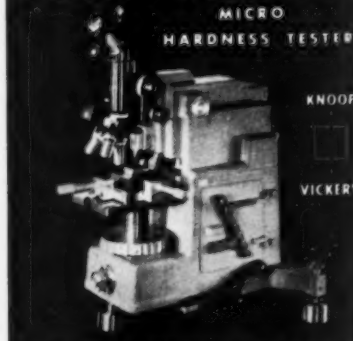
Detroit Testing Machine Company

9390 Grinnell Ave. • Detroit 13, Mich.

LIST NO. 54 ON INFO-COUPON PAGE 64

KENTRON

MICRO
HARDNESS TESTER



KNOOP

VICKERS

Applies 1 to 10,000 gram loads

Write for Bulletin

Kent Cliff Laboratories Div.

The Torsion Balance Company

CLIFTON

NEW JERSEY

LIST NO. 53 ON INFO-COUPON PAGE 64



**ALL TYPES OF
LABORATORY
FURNACES**

BY

Boder

Thermocouple Checking
Automatic Type
Tube Types—2000-5000° F.
Box Types—2000-5000° F.
Heat Treating
Salt Bath Tempering
Melting by Carbon Arc
Metallurgical Experiments
Atmosphere Annealing
Powder Metallurgy
Hardenability Test
Combustions
Carbon & Sulfur Det.
High Frequency Fusion

HIGH
FREQUENCY
COMBUSTION
UNITS

BOX TYPE FURNACES ▶

You tell Boder what you need

MANY TYPES OF TUBE
FURNACES

BODER SCIENTIFIC COMPANY

719 LIBERTY AVE., PITTSBURGH 22, PA.
PHONE: ATLANTIC 1-5525

LIST NO. 55 ON INFO-COUPON PAGE 64

MERIAM
MANOMETERS

U-TYPE • WELL TYPE • DUAL TUBE

FLOW METERS
DRAFT GAUGES

For measuring pressure, vacuum and differential pressure of liquids and gases. Also a complete line of accessories.

ASK FOR CATALOG C-12

THE MERIAM INSTRUMENT CO.
10932 MADISON AVE.
CLEVELAND 2, OHIO

U-TYPE MANOMETER

LIST NO. 48 ON INFO-COUPON PAGE 64

ULTRASONICS

for rapid, accurate, non-destructive
THICKNESS MEASUREMENTS from oneside
and accelerated **METAL CLEANING**

VIDIGAGE Automatic Thickness Tester

Direct-Reading 21" Cathode-Ray Tube. Infinite Ranges 2:1, as selected, between 0.015" and 6" of steel or equivalent. Accuracy 0.1%—1.0% according to use.

AUDIGAGE® Portable Thickness Testers

Battery-Operated. Ranges 0.020"—4" and 0.060"—12" of steel or equivalent

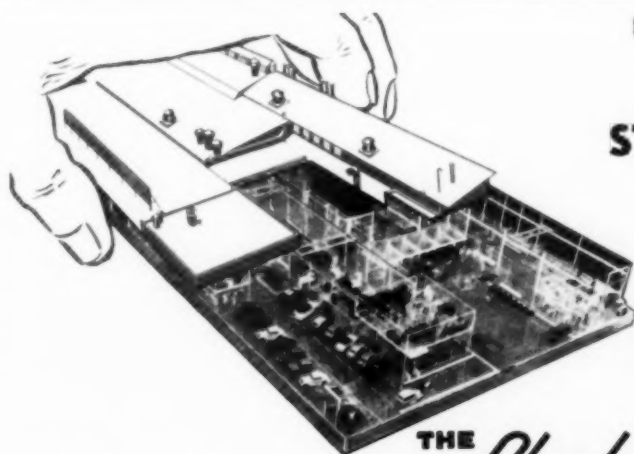
SONOGEN Ultrasonic-Power Generator
for Metal Cleaning and other industrial uses.

BRANSON electronics
INSTRUMENTS, INC. development
production

439 FAIRFIELD AVE • STAMFORD • CONN.

Literature
on Request

LIST NO. 81 ON INFO-COUPON PAGE 64



UNDER ONE ROOF . . . at **LAKE SIDE** **STEEL IMPROVEMENT**

Your most comprehensive, complete
scientific steel treating services

Electronic Induction Hardening, Carbonitriding, Flame
Hardening, Heat Treating, Bar Stock Treating and
Straightening (mill lengths and sizes), Annealing, Stress
Relieving, Normalizing, Pack, Gas or Liquid Carburizing,
Nitriding, Speed Nitriding, Aerocasing, Chapmanizing,
Cyaniding, Sand Blasting, Laboratory Physical Testing.

THE
Lakeside Steel Improvement Co.

5418 LAKE SIDE AVE., CLEVELAND 14, OHIO HENDERSON 1-9100

LIST NO. 43 ON INFO-COUPON PAGE 64

JUST PUBLISHED . . .

THE STORY OF MALCOMIZING

(For surface hardening stainless steels)

what it is . . . what it does . . . how it works
... how you can use it.

Write today for your copy of this 24-page
booklet. Specific subjects discussed include:
... pretreating the steel ... selective Mal
comizing ... case depth ... wear resistance
... corrosion resistance ... protection of
malcomized steel.

A special "case history" section shows
how nationally known manufacturers are
specifying Malcomizing for the surface
hardening of stainless steels.

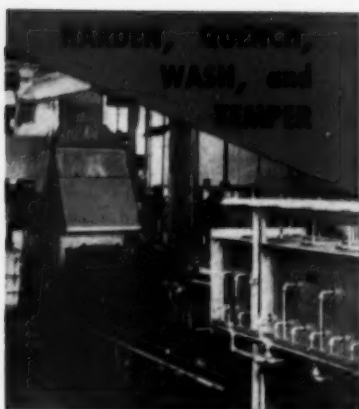
Lindberg Steel Treating Co., operating in
duplex stainless steel, steel in stock, with
plants in Rochester, Chicago, St. Louis and
Los Angeles, is now licensed to Malcomize
for its customers. For particulars call your
nearest Lindberg plant.

LINDBERG STEEL TREATING COMPANY
Malcom Park (Chicago), Illinois, Phone
Chicago 4-4422, St. Louis 19, Missouri, 524
E. Taylor, Phone Chicago 4-4422, Los
Angeles 21, 1978 South Coast Drive, Phone
California 6-7121, Rochester 11, 435 Buffalo
Road, Phone Chicago 5-1112

CHICAGO • LOS ANGELES • ROCHESTER • ST. LOUIS

LINDBERG STEEL TREATING CO.

LIST NO. 38 ON INFO-COUPON PAGE 64



**in one continuous operation
AUTOMATICALLY**

Parts are conveyed automatically through 2 gas-fired hardening furnaces and into the quench tanks, from which the lines converge for direct conveyance to the **METALWASH** Spray Washer, where quenching oil is removed prior to tempering.

The **METALWASH** Spray Washer conveys the work directly into the continuous tempering unit. Combination washing and tempering machines also available.

Write today for information about the **METALWASH** way to Heat, Quench, Wash and Temper AUTOMATICALLY.



METALWASH MACHINERY CORPORATION
908 North Avenue, Elizabeth 4, N. J.
In Canada, Canefco, Ltd., Toronto, Ontario

LIST NO. 117 ON INFO-COUPON PAGE 64

CIRC-AIR

HEAT TREATING FURNACES

for
Every Heat Treating
Process

★

**CONTROLLED
ATMOSPHERES**

★

DIRECT FIRED

★

**CIRC-AIR DRAW
FURNACES**

★

**CIRC-AIR NICARB
(CARBONITRIDING)**

◀ ○ ▶

*Specially Engineered
for
Your Particular Needs*

•

GAS • OIL • ELECTRIC

**INDUSTRIAL
HEATING EQUIPMENT
CORPORATION**

P.O. Box 1000, St. Louis 1, Mo.
Cincinnati, Ohio

LIST NO. 19 ON INFO-COUPON PAGE 64

HERE'S HELP for your engineer- recruitment problem

*Engineers' Joint Council
and The Advertising Council
offer free, expert help to
advertisers promoting engi-
neering as a career.*

A booklet has been prepared by The Advertising Council in cooperation with the Engineers' Joint Council to help you in recruiting engineers for the future.

1. It tells you what the problem is and the important part you can play in solving it.
2. It outlines the advantages of an engineering career to help your company develop advertising appeals.
3. It informs you as to the current activities of industry in the education and recruitment of engineers.
4. It offers specific suggestions as to what you can do (from present manpower).
5. It provides material that you can use in your own local and national programs.

Many companies are using this booklet today. They say that it helps in orienting their engineer-recruitment advertising to industry-wide recruitment programs. Send for the booklet now. Address: The Advertising Council, Inc., 25 West 45th St., New York 36, N.Y.

*This space contributed by
American Society for Metals*



Style #13 in salt hardening bath application.

Representative inquiries invited.
Specialists in Processing Carriers Since 1932

Wiretex mfg. co.
5 Mason St., Bridgeport 5, Conn.

LIST NO. 114 ON INFO-COUPON PAGE 64

FOR ALL YOUR BASKET and FIXTURE NEEDS ...

Call Wiretex

Wiretex has the facilities to serve your every need. Stock, large, standard or custom built. To finish, acid, heat, abrasion or temper. In every shape, metal and alloy. Price it to yourself—send for the booklet.

BASKETS
MUFFLES
SCREENS

• **RETORTS**
• **GRIDS**
• **RACKS**

for Quenching, Carburizing,
Salt Bath, Dry Heat Applica-
tions, etc.

INDUSTRIAL FUEL BURNING EQUIPMENT.

Designed **FOR YOUR SPECIFIC REQUIREMENTS**

- Motor-Mix Burners
- Model DA Mixers
- Western Safety Valves
- Injector-Mix Burners
- Flame Retention Nozzles
- Accessories
- Inspirator-Mix Burners
- Blowers
- Multiport Burners
- Custom Built Equipment

Free descriptive literature on request

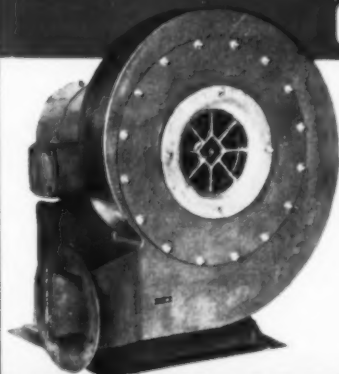


WESTERN PRODUCTS, Inc.

General Office 549 W. Washington Blvd.
New Castle, Ind. Chicago 6, Ill.

LIST NO. 93 ON INFO-COUPON PAGE 64

Combustion Air Blowers



Single Stage
8 oz. to 20 oz. Pressures

- Designed to meet your capacity and pressure requirements.
- Maximum Efficiency—power consumption is proportional to air volume delivery
- Constant Pressures assured through properly designed case, air inlet and impeller

Write for Bulletin 100-53

Manufactured
by

WESTERN PRODUCTS, INC.
NEW CASTLE, IND.

LIST NO. 115 ON INFO-COUPON PAGE 64

Upton

... OFFERS
the most advanced
Salt Bath Furnaces
FOR ...

**BATCH
TYPE
WORK**

o

**CONVEYORIZED
TYPE
WORK**

o

**ALUMINUM
BRAZING**



UPTON ELECTRIC FURNACE CO.
16808 Hamilton Avenue
Detroit, Michigan
Phone: Diamond 1-2520

LIST NO. 20 ON INFO-COUPON PAGE 64

**YOU
Name it...
WE'LL
Supply it!**

We make containers and fixtures of all types—
for handling parts in heat treating, quenching,
pickling, washing and anodizing operations.
If what you need isn't shown in our catalog,
we'll design and build it for you.

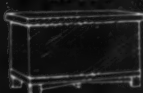
REPRESENTATIVES IN PRINCIPAL CITIES

Stanwood
4817 W. CORTLAND ST.

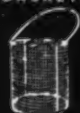


Corporation
CHICAGO 39, ILLINOIS

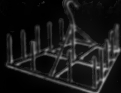
CARBURIZING
BOXES



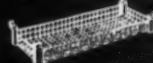
BASKETS



FIXTURES



TRAYS



QUENCH TANKS



RETORTS



LIST NO. 12 ON INFO-COUPON PAGE 64

3 SIMPLE STEPS... TO SOLVE ALL YOUR HEAT TREATING PROBLEMS!



Coat piece with Phoenix Brand NON-SCALING COMPOUND, a dry, easy-to-handle powder.



Harden or anneal piece as normally required — powder forms protective coating completely sealing piece from air.



If necessary, boil in plain water to remove protective coating. Coating comes off quickly, easily—

giving you a bright scale-free, pit-free surface like

THIS . . . not THIS —



EVERY TIME!

Save TIME! Save MONEY!
Send for a trial order TODAY!
— Satisfaction guaranteed —

2 lb. can — \$6.00	ORDER TODAY FROM
5 lb. can — \$15.00	YOUR LOCAL
15 lb. can — \$41.25	DISTRIBUTOR
25 lbs. or more — \$2.50 per lb.	OR WRITE

THE PARKER STAMP WORKS, Inc.
ESTABLISHED 1871
HARTFORD, CONNECTICUT

LIST NO. 120 ON INFO-COUPON PAGE 64

Expand Your Plant Potential

WITH *Cooley* ELECTRIC HEAT TREATING FURNACES

fast . . . inexpensive way to expand your plant facilities. Choose from 27 Models.

- For instance:**
1. You save time and money by keeping heat treat jobs for small parts in plant.
 2. It's easy to establish a new department at small cost in proportion to benefits which result.
 3. Cooley heat treat furnaces pay for themselves through savings in time and subcontracting costs.
 4. Heat treat operations are easily performed with Cooley designed furnaces.

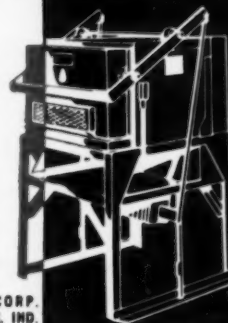


Write now for Catalog giving complete details.

Cooley

ELECTRIC MANUFACTURING CORP.
38 SO. SHELBY ST. • INDIANAPOLIS, IND.

LIST NO. 87 ON INFO-COUPON PAGE 64



Spotlighting DETROIT'S BETTER HEAT TREATER



OFFERING FACILITIES FOR:

1. ALUMINUM—CAP. 500,000# PER MO.
2. MINUTE PARTS TO 2-TON DIES
3. BRIGHT HARDENING OF STAINLESS STEEL

ALL TYPES OF HEAT TREATING CAN BE DONE BETTER BY

STANDARD STEEL TREATING CO.

3467 LOVETT AVE. DETROIT 10, MICH.

Phone TA 5hmoo 5-0600

LIST NO. 40 ON INFO-COUPON PAGE 64

DEMPSEY FURNACES

GAS, OIL AND ELECTRIC
BATCH • CONTINUOUS

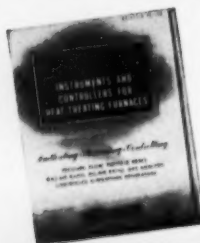
ATMOSPHERIC • RECIRCULATING •
PUSHER • ROTARY HEARTH •
CONVEYOR • RADIANT TUBE • POT
CAR-BOTTOM • ALUMINUM REVERBS.
"Tailored by Dempsey"



DEMPSEY INDUSTRIAL FURNACE CORP.
Springfield 1, Mass.

LIST NO. 79 ON INFO-COUPON PAGE 64

Instruments and Controllers for heat treating furnaces



A complete summary of Hays products applicable to processes such as annealing, brazing and carburizing. Scope includes various methods of firing (underfired, overfired, sidefired), fuel burned (gas, coal, oil), and type of furnace (continuous, rotary hearth, slab heating, etc.).

Hays complete line of draft gages, flow gages and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO₂ recorders are covered.

Write for bulletin 51-750-51

THE HAYS CORPORATION

Madison City 24, Indiana

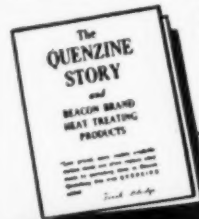
LIST NO. 30 ON INFO-COUPON PAGE 64

METAL PROGRESS; PAGE 60

FREE

the QUENZINE STORY

Low priced, more readily available carbon steels can often replace alloy steels when quenched in Beacon Quenching Oils with QUENZINE added. For information on this new additive and other Beacon Brand Heat Treating Compounds write to . . .



**ALDRIDGE
INDUSTRIAL OILS, Inc.**

3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 29 ON INFO-COUPON PAGE 64

STEELWELD Bending Presses and Shears

Built for Heavy-Duty Long-Life Service



For Press data write
for Catalog No. 2010.

Steelweld machines have an enviable reputation throughout the United States and the world for their ease of operation and low-maintenance performance. Complete line for metal from light gauge to 1 1/2" and lengths to 24'-0". Representatives in all principal cities.



For Shear data write
for Catalog No. 2011.

The Cleveland Crane & Engineering Co.
5952 East 281 Street
Wickliffe, Ohio

LIST NO. 59 ON INFO-COUPON PAGE 64

ENGINEERING ALLOYS

by N. E. Woldman

This up-to-the-minute book lists over 19,000 alloys by trade name and gives their properties, compositions and typical applications. All important commercial alloys are shown.

1056 pages of valuable information, generous index and tables of manufacturers and the trade names of their products.

Price, \$15.00

AMERICAN SOCIETY FOR METALS
7301 Euclid Ave. Cleveland 3

FROM BLANK TO FINISHED PART IN ONE OPERATION by SCHNELL PROCESS of Deep Draw Dies

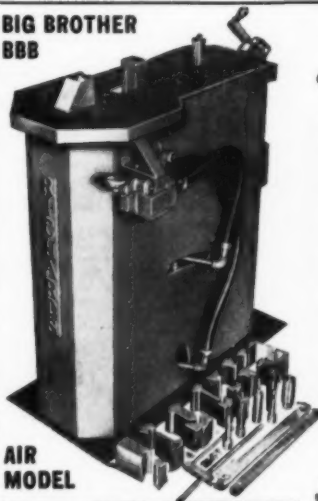
On half tank sections formerly requiring three drawings and two annealing operations with scrap running as high as 50%! The Schnell process reduced scrap loss to 1% or less . . . and production increased tremendously. Other advantages include better metallurgical properties, less metal distortion and a more uniform wall thick-

ness. Whatever your stamping, drawing or die problem may be, there is a Schnell process for doing the job faster, more efficiently and less expensively. Schnell has complete engineering and plant facilities. Write for information on how you too may eliminate operations and reduce production costs.

SCHNELL
TOOL & DIE CORP.
SALEM, OHIO

LIST NO. 118 ON INFO-COUPON PAGE 64

BIG BROTHER BBB



**AIR
MODEL**

Multiform

• SAVE ON SET UP TIME

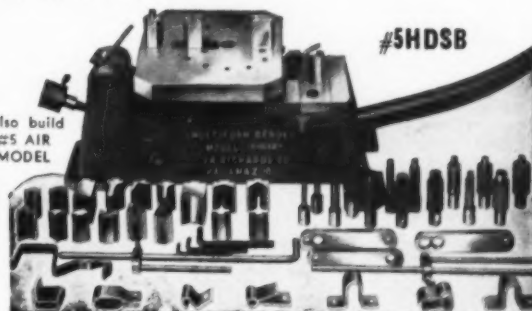
• REDUCE PRODUCTION TIME • ELIMINATE SPECIAL TOOLING • FOR BENDING ALL KINDS OF MATERIAL UP TO 1/4" x 4"



Illustrated above are a few of the many forms that can be produced efficiently on the Multiform Bender, using the standard tooling.

WRITE TODAY FOR
FULL INFORMATION

Also build
#5 AIR
MODEL



#5HDSB

J. A. RICHARDS CO. • 913 N. Pitcher St. • Kalamazoo, Michigan

LIST NO. 107 ON INFO-COUPON PAGE 64

Send for your
FREE Sample Tube
of this Amazing
New Lubricant

Molylube
ANTI-SEIZE



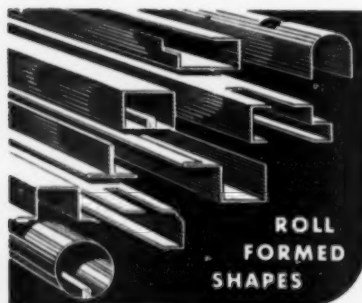
Prove to yourself its extraordinary performance

Molylube Anti-Seize is a highly concentrated non-melting molybdenum disulphide grease having the phenomenal capacity to prevent galling and seizing at bearing pressures well over 100,000 pounds per square inch. It has excellent lubricating qualities at low temperatures and elevated temperatures up to 750°F.

BEL-RAY COMPANY, INC.

MADISON, NEW JERSEY

LIST NO. 111 ON INFO-COUPON PAGE 64



Reduce your assembly problems and costs. Our shapes continuously formed, with high degree of accuracy, from ferrous or non-ferrous metals. Write for Catalog No. 1053.

ROLL FORMED PRODUCTS CO.

MAIN OFFICE AND PLANT
3761 OAKWOOD AVE. • YOUNGSTOWN, OHIO
LIST NO. 101 ON INFO-COUPON PAGE 64

METAL PROGRESS; PAGE 62

Cut Costs With **FREE** Cutting Oil Chart

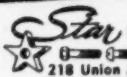
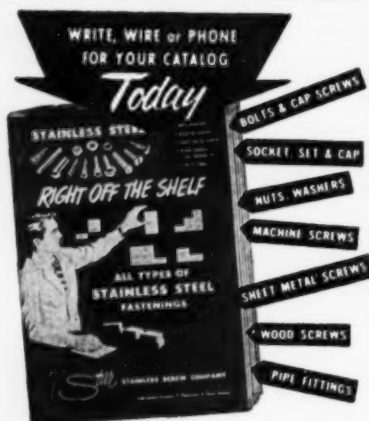
Use this free cutting oil chart as a handy guide to production costs and to more efficient machining operations. Steel and nonferrous metals are charted with the proper cutting oil for many applications. Shows you how to use lubricants, sulphurized or compounded with extreme pressure additives, for all operations.



**ALDRIDGE
INDUSTRIAL OILS, Inc.**

3401 W. 140th St., Cleveland 11, Ohio

LIST NO. 100 ON INFO-COUPON PAGE 64



STAR STAINLESS SCREW CO.

ARMORY 4-1240
218 Union Avenue • Paterson 2, N.J.
Direct NEW YORK Telephone: WI 7-9041

LIST NO. 4 ON INFO-COUPON PAGE 64

ask SESSIONS HOW STAMPED ASSEMBLIES SAVE TIME & MONEY

Send samples
or prints for
quotations
on special
stampings and
sub-assemblies.



J. H.
SESSIONS
E. SON

291 RIVERSIDE AVENUE • BRISTOL, CONN.
LIST NO. 119 ON INFO-COUPON PAGE 64

Prove!
it!

Prove to your own satisfaction that the MOLYKOTE line of industrial lubricants is one of the most spectacular contributions to metal progress in many decades. Send for free literature today and then order a trial supply.

MOLYKOTE®
INDUSTRY'S MOST
VERSATILE LUBRICANT

The tremendous lubricity of MOLYKOTE depends on the unique molecular structure of the compound. Read the story behind its development and the jobs it can do better than any other lubricants.

Send for free catalog today!

THE ALPHA CORPORATION

LIST NO. 110 ON INFO-COUPON PAGE 64

Plan to Attend the **METAL SHOW**

Chicago

November 1 to 5

1954

CENTRIFUGAL CASTINGS...

Better

for most castings

Best

to prevent gas and
liquid leaks

For details, write for booklet,
American Non-Gran Bronze Co.,
Berwyn, Pa.



LIST NO. 3 ON INFO-COUPON PAGE 64

**Metal Progress is now
in its Second year as
one of our clients**

Ray Eastman

The Eastman Editorial Research Service is a critical and advisory service to publishers for the sole purpose of developing and maintaining better readership.

Exclusive to one publication in a field.

Use of the Eastman service by Metal Progress is an implied guarantee to its readers of continuing editorial progress.

The Eastman Research Organization
500 5th Avenue • New York 36, N. Y

GET A BID FROM

HOOVER

SPECIALISTS IN THE FIELD OF

Die Castings

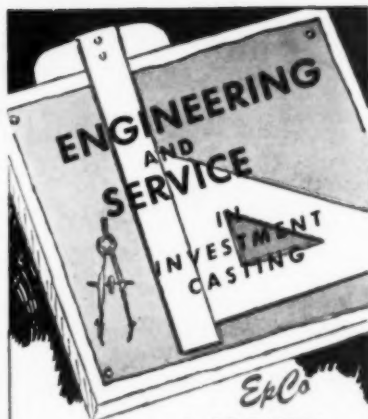
SINCE 1922

Aluminum and Zinc



THE HOOVER COMPANY
Die Castings Division
North Canton, Ohio

LIST NO. 74 ON INFO-COUPON PAGE 64



**A PROVEN
DEPENDABLE SOURCE
FOR BETTER GRADE INVESTMENT
CASTINGS IN FERROUS AND
NON-FERROUS METALS**



INVAR
CASTING
Special Feature
— Nickel content
held to 35% min-
imum — 36%
maximum

STAINLESS STEEL PART for milk
bottling unit formerly machined
from solid stock.
Only finish oper-
ations required
are reaming small
dia. of counter-
bored hole and
drilling and tap-
ping for set screw.



**ENGINEERED
PRECISION CASTING CO.**

MORGANVILLE, N. J.

LIST NO. 4 ON INFO-COUPON PAGE 64

**A CABLE SPLICED
IN 10 SECONDS!**



ERICO PRODUCTS, INC.

Complete Arc Welding Accessories

2070 E. 61st Place, Cleveland 3, Ohio

Write for Caddy Catalog

LIST NO. 71 ON INFO-COUPON PAGE 64

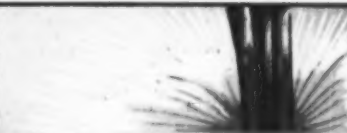


*Call on Mr.
Electrode*

**See
Maurath, Inc.
For**

**Stainless and
Heat Resistant
ARC WELDING
ELECTRODES**

**AUTOMATIC WELDING
All Analyses - Coated,
Straightened - Cut -
Coiled and Spooled**



MAURATH, Inc.

21830 MILES AVENUE

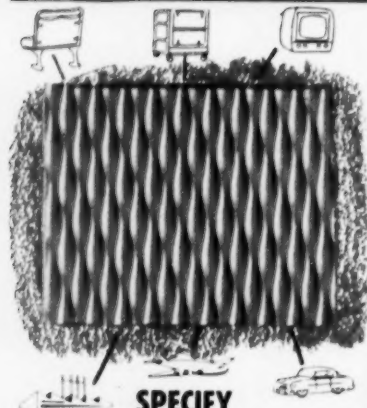
NORTH RANDALL 22, OHIO

Phone: MOntrorse 2-6100

LIST NO. 72 ON INFO-COUPON PAGE 64

METAL PROGRESS; PAGE 63

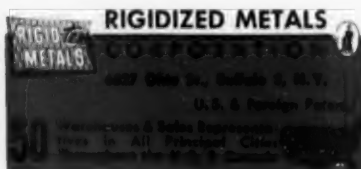
**STRENGTHEN
BEAUTIFY
PROTECT
your product**



**SPECIFY
RIGID-tex METALS**

Take that new product of yours, make it dent-scruff-scratch-resistant, give it plenty of rugged impact resistance, reduce its weight and double its strength, and finish it up by packing it full of buying-eye appeal. You can do all this when you specify Rigid-Tex Metals right into your product designs! Find out for yourself.

Send for new 16-page complete catalog—on company letterhead, please—or see *Sweets Catalog la/Ri*.



LIST NO. 64 ON INFO-COUPON BELOW

USE OUR
**HOEGANAES
SPONGE IRON POWDER**

for
*Powder Metallurgy
Fabrication
and other
Metallurgical Purposes*

EKSTRAND & THOLAND, Inc.
441 Lexington Avenue
New York 17, N. Y.

LIST NO. 63 ON INFO-COUPON BELOW



"SILVERCOTE"®
**BERYLLIUM
COPPER**

TITANIUM • BRONZES • ALUMINUM
COPPERWELD • SILVER PLATED WIRES
OTHER NON-FERROUS

ROUND WIRE FLAT
for
* SPRINGS
* FORMS
* ELECTRONICS
* SPECIAL PURPOSES

LITTLE FALLS ALLOYS
INCORPORATED
189 Caldwell Ave. • Paterson 1, N. J.

LIST NO. 66 ON INFO-COUPON BELOW

**WHITELIGHT
MAGNESIUM**

your comprehensive independent
source of magnesium alloy
Tubes • Rods • Shapes • Bars
Hollow Extrusions • Plate • Sheet
• Pipe • Wire • Welded and
Riveted structures and assemblies



**WHITE METAL ROLLING
& STAMPING CORP.**

82 Moultrie St., Brooklyn 22, N. Y.
Sales Office
876 Lafayette St., New York 3, N. Y.

LIST NO. 67 ON INFO-COUPON BELOW

**The
Metals
Handbook**

1332 Large pages
1752 Illustrations
1057 Tables
803 Articles
1,620,000 Words
40,000 Copies in use



Here is a book without a competitor.... a book written by more than 500 scientists and engineers for all those who need accurate and authoritative information about metals. The Metals Handbook has been 25 years in the making. The current, 7th edition was compiled and written by 68 committees of the American Society for Metals; more than 500 contributors were hand-picked by the Society as the top experts, the men best qualified to write the most authoritative possible reference book on metals, metal properties, fabrication and uses. The book is divided into 37 principal sections and contains 803 separate articles and data sheets on metals, properties, uses, processing, testing, inspection, control and research. All metals, all processes, are included. The 64-page index and 4-page section on how to use the book make it easy to find what you want.

Over 40,000 copies of this edition are now in use by scientists and engineers of all kinds who need accurate information about metals. Order your copy of the 1948 edition today. Price is \$15.00.

American Society for Metals, Room 678
7324 Euclid Ave., Cleveland 3, Ohio
Rush me a copy of Metals Handbook.

NAME _____
COMPANY _____
ADDRESS _____
CITY _____ STATE _____
☐ \$15.00 Enclosed ☐ Bill me.

READERS' INFO-COUPON SERVICE, METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

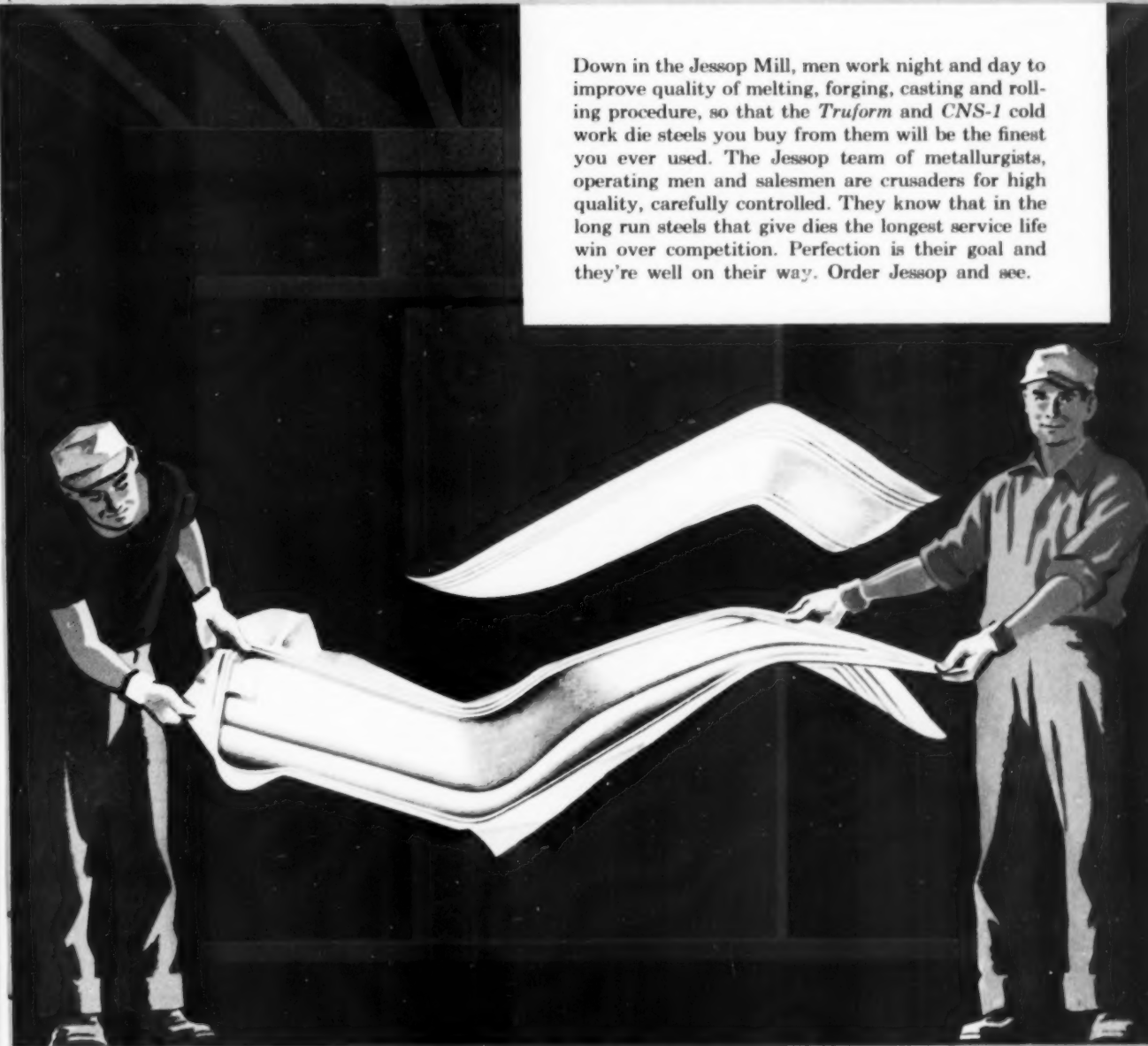
Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

	(Please check)		
	Send Catalog or Engineer- ing Data	Send Price Info	Nearest Source of Supply
(Bulletin Board Item Number)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Your Name _____ Title _____
Company _____
Street _____
City _____ Zone _____ State _____

Jessop steel is designed to bring longer life to your dies

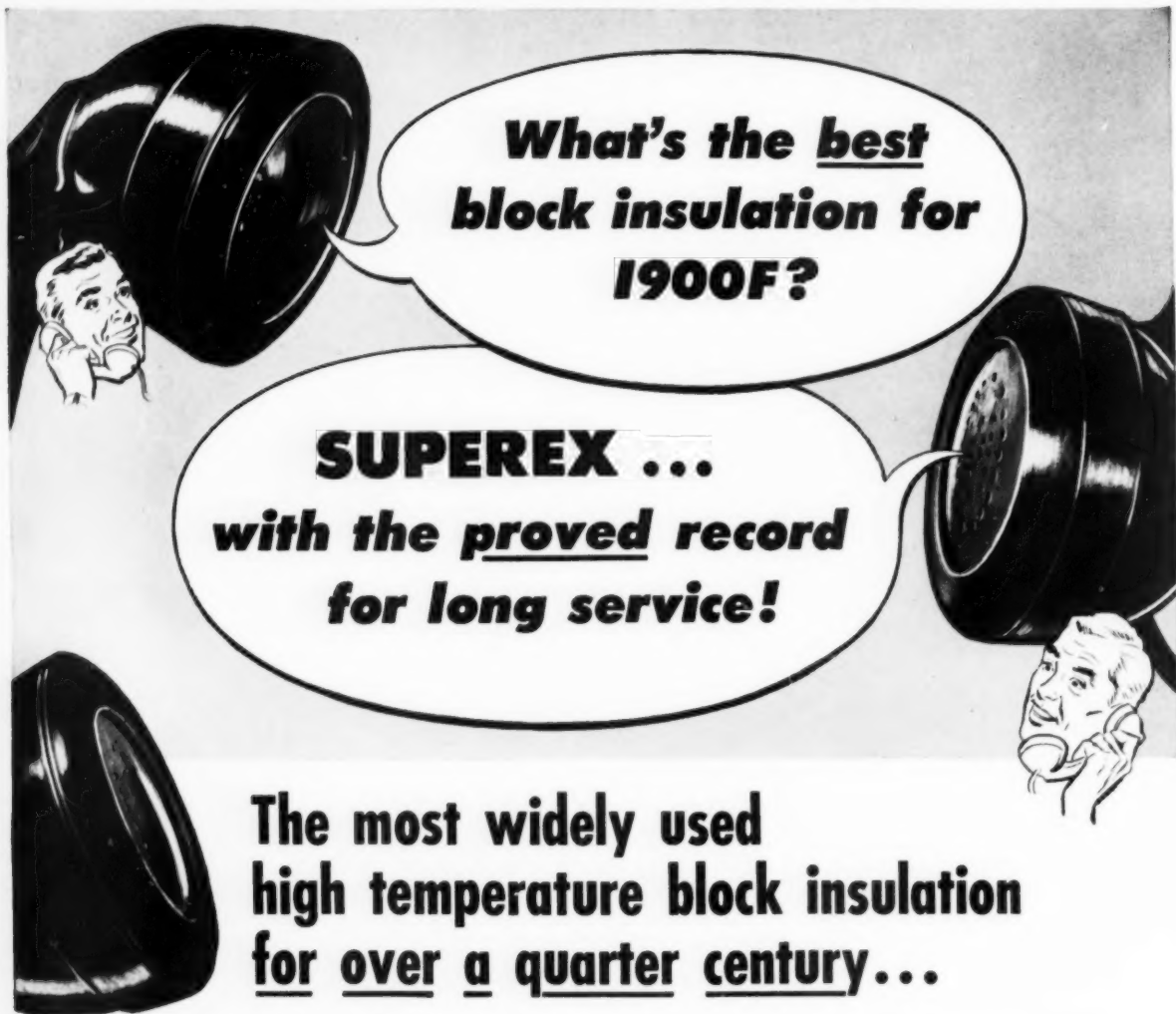
Down in the Jessop Mill, men work night and day to improve quality of melting, forging, casting and rolling procedure, so that the *Truform* and *CNS-1* cold work die steels you buy from them will be the finest you ever used. The Jessop team of metallurgists, operating men and salesmen are crusaders for high quality, carefully controlled. They know that in the long run steels that give dies the longest service life win over competition. Perfection is their goal and they're well on their way. Order Jessop and see.



STAINLESS STEELS • HIGH SPEED STEELS • NON-MAGNETIC STEELS • HIGH SPEED TOOL BITS • HEAT RESISTING STEELS • STAINLESS-CLAD PLATES • CARBON AND ALLOY STEELS • TOOL STEELS FOR SPECIAL PURPOSES • CAST-TO-SHAPE TOOL STEELS • HIGH SPEED AND ALLOY SAW STEELS • TEMPERED AND GROUND STRIP STEEL • COMPOSITE HIGH SPEED STEELS • STAINLESS AND HEAT RESISTING CASTINGS • COMPOSITE DIE STEEL SECTIONS • PRECISION GROUND FLAT STOCK • DIE STEELS—HOT AND COLD WORK

JESSOP

STEEL COMPANY • WASHINGTON, PA.



What's the best block insulation for 1900F?

SUPEREX ... with the proved record for long service!

The most widely used high temperature block insulation for over a quarter century...

SUPEREX® high temperature block insulation has long been industry's No. 1 choice for service temperatures up to 1900F. It provides *major* economies . . . reduces fuel costs, cuts heat losses, keeps maintenance expense down, costs less to install and has long service life.

These are the reasons why 90% of the nation's hot blast stoves are Superex insulated . . . and why the low cost open hearth steel producers use Superex in their regenerators.

Made of specially selected and calcined diatomaceous silica blended with other insulating materials and bonded with asbestos fiber, Superex will safely withstand temperatures up to 1900F with negligible shrinkage.

Superex has been used with outstanding success in all types of industrial and metallurgical furnaces and ovens, stationary and marine boilers, auxiliary power plant equipment, regenerators,

kilns, roasters, high temperature mains, flues and stacks.

Superex has all these important advantages...

Low thermal conductivity—Exceptionally high heat resistance (1900F) combined with excellent insulating value.

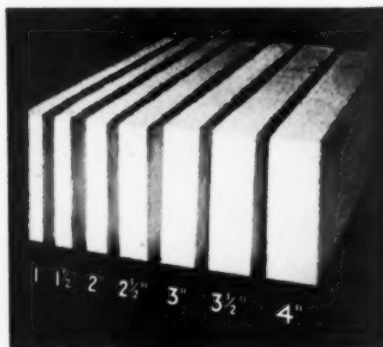
Light weight—Approximately 2 lb per sq ft per in thickness.

Great physical strength—Approximately 6 tons pressure per sq ft are required to compress Superex $\frac{1}{8}$ in.

Long, efficient service life—Superex maintains high insulating value indefinitely—will not disintegrate in the service for which it is recommended.

Fast, easy application—Superex may be cut with an ordinary knife or saw for fitting around openings or to irregular surfaces. Because of its light weight and convenient size, Superex assures fast and economical installations.

For complete information about Superex block insulation, write for Brochure IN-134A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, write 199 Bay Street, Toronto 1, Ontario.



Waste is minimized with Superex because of the variety of thicknesses available. Special shapes and intermediate thicknesses between those shown are also available.



Johns-Manville

first in

INSULATIONS



check with the standard
... and with high speed steels
the standard is REX

It's easy to check on Junior's vision these days with *standard* eye charts. And for half a century there's been a *standard* in tool steels, too — Crucible REX® High Speed Steel.

Try REX High Speed Steel in your own shop as thousands all over the world have done. Use it under the toughest conditions . . . compare its performance with all other high speed steels. You'll find that *absolutely nothing beats REX*.

That's because REX High Speed Steels are unsurpassed in structure, finish, carbide distribution, response to heat treatment and general uniformity. So, on your next purchase of high speed steel, specify REX — made only by Crucible.



CRUCIBLE

first name in special purpose steels

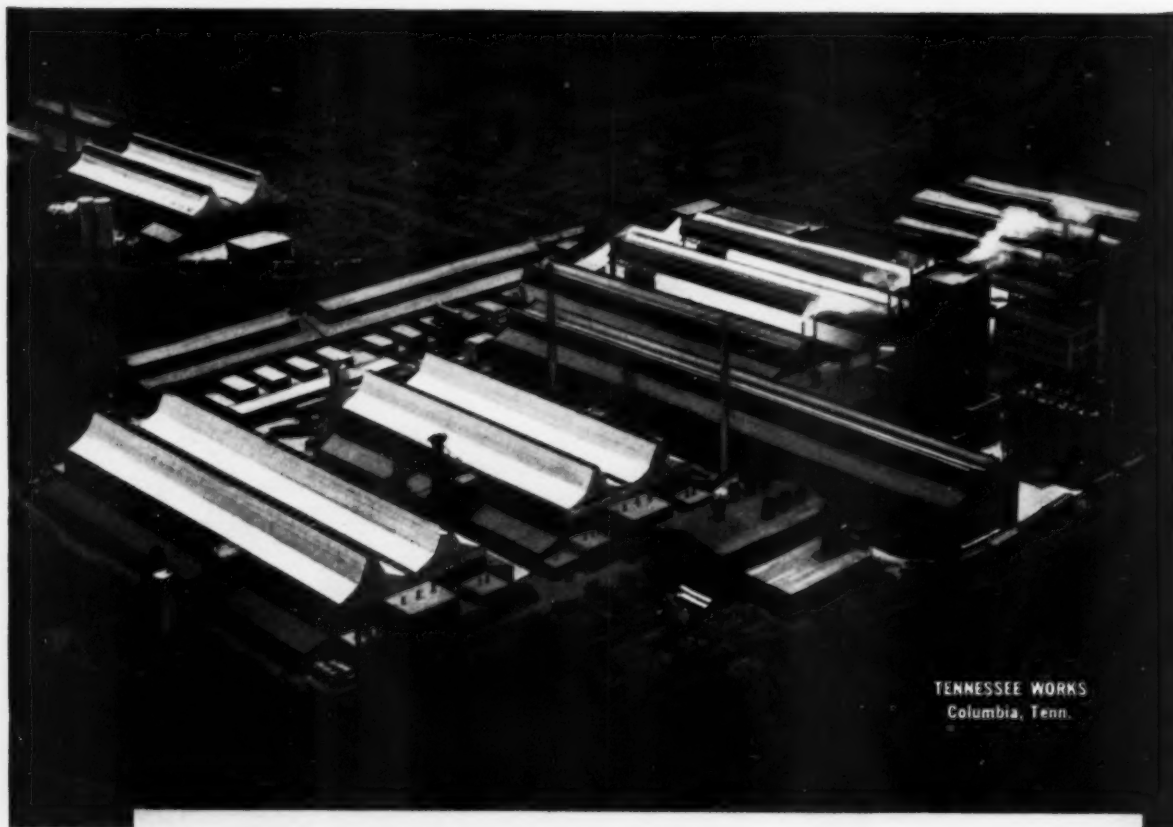
54 years of *Fine* steelmaking

TOOL STEELS

CRUCIBLE STEEL COMPANY OF AMERICA • TOOL STEEL SALES • SYRACUSE, N. Y.

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

SEPTEMBER 1954; PAGE 65



TENNESSEE WORKS
Columbia, Tenn.



CLARKSBURG WORKS
West Virginia

FIVE REASONS WHY NATIONAL CARBON COMPANY **ELECTRIC FURNACE ELECTRODES GIVE YOU THE** **MOST FOR YOUR MONEY...**

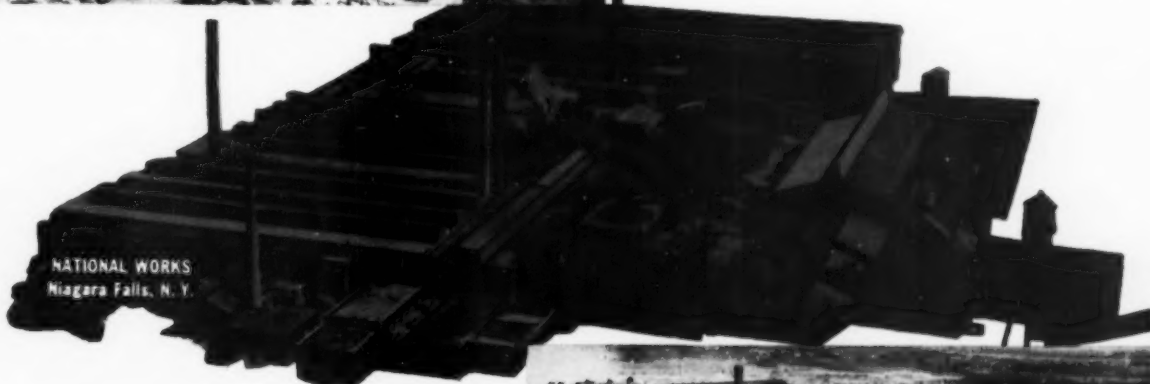
ELECTRODE QUALITY . . . has a direct bearing on the quality of *your* product; in many instances, it can materially affect your *cost*. National Carbon's graphite and carbon electrodes are, and always have been, the finest quality obtainable *anywhere*. We make this statement without reservation.

NEW PRODUCT DEVELOPMENT . . . is basic in technological progress. National Carbon has *always* done the major part of this country's electrode research and development . . . a share out of all proportion even to its outstanding leadership in the production and sale of these products. This is a matter of long-standing record.



ACHESON WORKS
Niagara Falls, N. Y.

PLANT CAPACITY . . . National Carbon's ability to *produce* is at an all-time high. The five plants shown here are fully integrated for production of both carbon and graphite electrode products — a situation rare in the industry and in keeping with National Carbon's far-sighted planning to pace requirements of a rapidly-expanding economy. For example, plant additions in the last five years alone have more than doubled graphite electrode capacity.



EXPERIENCE . . . of National Carbon is the foundation, building blocks and cornerstone of electrode-products manufacture in this country. First with commercial production of both carbon and graphite electrodes in the early 1900's, National Carbon introduced the first of each increasingly larger electrode size from that time to the present, plus a host of successful accessory items for improved application of electrodes in the metallurgical field. Today, National Carbon is the only company producing carbon electrodes up to 45" diameter; graphite electrodes to 35". Even larger electrodes and other massive shapes can be made with present facilities. Inquiries are invited.



REPUBLIC WORKS
Niagara Falls, N. Y.

RESPONSIBILITY . . . to customers and to the industry as a whole . . . expresses itself several ways in National Carbon history. The company has consistently kept ahead of demands for both quality and size of electrode products; National Carbon research stands virtually alone in the steady march of new product development; and, in the field of *service*, National Carbon is supreme. For many years we have conducted an expanding, electrode technical-service operation, staffed by a group of electrode experts, specially trained to help you get *more for your electrode dollar*.

The terms "National" and "Acheson" are registered trade-marks of Union Carbide and Carbon Corporation

NATIONAL CARBON COMPANY

A Division of
Union Carbide and Carbon Corporation
30 East 42nd Street, New York 17, N. Y.

District Sales Offices:
Atlanta, Chicago, Dallas, Kansas City,
New York, Pittsburgh, San Francisco

IN CANADA:
Union Carbide Canada Limited, Toronto

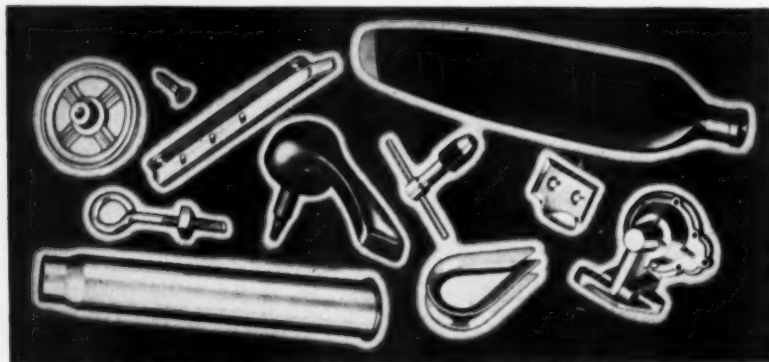


News about COATINGS for METALS

Metallic Organic Decorative Protective

Extra opportunities to cut costs with zinc finishing

*Wider choice of corrosion resisting
chromate finishes being offered*



Some of the many products finished in Unichrome Dips or Anozinc

CHROMATE treating still remains one of the best ways to finish zinc die castings or zinc plated steel. It strengthens corrosion resistance. It's an *easy* way to finish. It's economical. And time has proved its quality.

With such a combination of virtues offered in a finish, it pays designers, metal finishers and production men to review their products—and to evaluate the benefits of chromate finishing against their finishing requirements. Especially today—when the pressure is on to cut costs every possible way.

Through the unusually wide choice of finishes Unichrome Chromium provides, even greater benefits become possible. Here's why. A more economical dip solution may be chosen. Or a production advantage may be realized.

FOR EXAMPLE:

The right Unichrome Dip meant half the material consumption and longer solution life to one company.

Brighter finish on zinc plated hard-

ware with less solution-waste was gained in another plant with still another compound.

Chromate treating of zinc plated steel shell cases done electrolytically with Anozinc is found best and cheapest in the long run by many producers.

HERE IS VARIETY

Unichrome chromate finishes offer a good color choice. Lustrous, clear bright finish or black—brassy yellow or olive drab—even brass-color—all these can be produced chemically by Unichrome Dip solutions.

Unichrome chromate finishes also satisfy production method requirements. Compounds are available for manual or automatic operation.

An exclusive electrolytic process, Anozinc* rounds out this complete line of conversion coatings. It's found especially economical in continuous, large run automatic production. This process permits finished parts to be handled while wet.

Write for more data. *Trade Mark

66% more chromium plating with same current source

One company, only able to plate six bumper bars per load, made a tremendous improvement by means of a simple change. They merely switched to a Unichrome SRHS Chromium Solution—and found that ten pieces of work per load could be covered with fewer rejections, all without any need for a larger current supply. That's good proof of the better coverage, higher efficiency and greater economy that "SRHS" offers. Write for Bulletin SRHS-2.

Sprayable plastisol builds up thick coating without sagging

First successful sprayable vinyl plastisols, the Unichrome Series 5300 Coatings can be applied even to vertical cold metal surfaces without sagging. Cured coating film up to 25 mils thick can be produced in a single application. Now even large areas can get the amazing protection against corrosion and wear offered by these non porous, chemical resisting, chip-proof coatings. Send for Bulletin VP-1.

HELPFUL HINTS

by "Mr. Cost Cutter"



For true economy in an organic finish, base your specifications on both quality and applied cost—rather than on misleading cost-per-gallon. Consider 3 flat black finishes for wrought iron, for example:

	applied cost/sq. ft.
Coating "A"	1.2 to 1.3¢
Coating "B"	0.8 to 0.9¢
Coating "C"	0.8 to 0.9¢

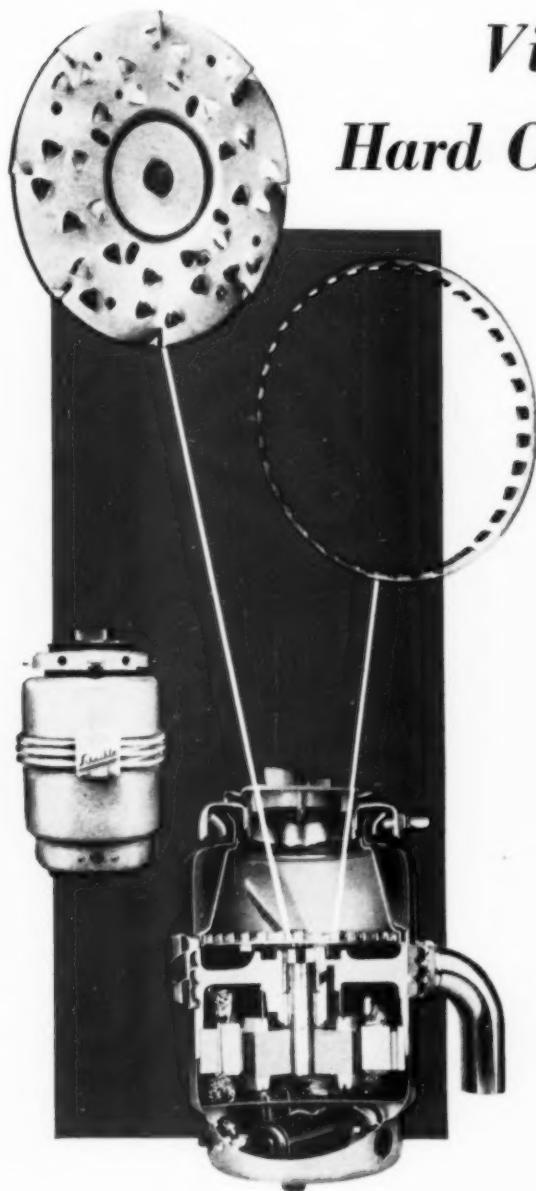
A Unichrome epoxy resin type finish, Coating "C" sells for twice as much per gallon as the other two, yet it not only gives best "mileage" but also a better looking, more durable and corrosion resistant finish.

UNITED CHROMIUM, INCORPORATED

100 East 42nd St., New York 17, N. Y.
Detroit 20, Mich. • Waterbury 20, Conn.
Chicago 4, Ill. • Los Angeles 13, Calif.

In Canada:
United Chromium Limited, Toronto 1, Ont.

The Schaible Story:



The new grinding principle of the Schaible Food-Waste Disposer is shown here. Particle discharge size is positively controlled by reduction grating through horizontal milling action, impingement cutting and clipping. The snag-toothed cutter and the clip ring used in this process require hardness and toughness. Park-Kase 5-C gives these tools the necessary hard case for years of efficient, dependable service.

Fifth in a series of advertisements describing Park processes on the job

Vital Grinder Parts Hard Cased in Park-Kase 5-C

Maximum Hardness at LESS COST for Schaible Cutter Disc and Clip Ring!

At the Schaible Company the grinding elements used in the production of the Schaible Food-Waste Disposer are precision hard cased with water soluble Park-Kase 5-C. Result: a higher hardness which means longer life and greater efficiency for these fast-action grinding teeth . . . *in less time and at less cost.* Here's why:

The rapid and uniform case depth of Park-Kase 5-C liquid carburizer means fast, reproducible cases which can be held to close limits for accurate, dependable work at temperatures up to 1700°F. Park-Kase 5-C produces eutectoid carbon cases which contain enough nitrogen to be file hard after oil quenching. High penetration rates and ease of cleaning are combined for ideal carburizing conditions. Inexpensive, simple, and trouble-free . . . Park-Kase 5-C lowers production costs.

- Lightness of Original Charge and Reduction of Salt Drag-out Keeps Costs Down.
- Does Not Foam While Operating.
- Water Solubility Means Time Saved on Oil Quenched Work.
- Needs No Special Complicated Mixing Procedures.

Complete details of the Park-Kase 5-C Carburizing process covering all phases of its operations are described in a technical bulletin available by mailing the attached coupon.

• Liquid and Solid Carburizers • Cyanide, Neutral, and High Speed Steel Salts • Coke • Lead Pot Carbon • Charcoal • No Carb • Carbon Preventer • Quenching and Tempering Oils • Drawing Salts • Metal Cleaners • Kold-Grip Polishing Wheel Cement



PARK CHEMICAL CO.

8074 Military Avenue • Detroit 4, Michigan

Send Free Bulletin Describing Park-Kase 5-C

Name _____ Position _____

Company _____

Address _____

City _____ State _____

Metals for

Industrial Machinery

GLC GRAPHITE ELECTRODES help make the metals required for the manufacture of industrial equipment, large and small.

The performance of GLC GRAPHITE ELECTRODES is unsurpassed in the processing of electric steels, foundry castings, ferroalloys and magnesium. Our facilities have been greatly expanded to keep pace with the growing emphasis on electric furnace steel production.

ELECTRODE DIVISION

Great Lakes Carbon Corporation

Niagara Falls, N. Y.



Morganton, N. C.



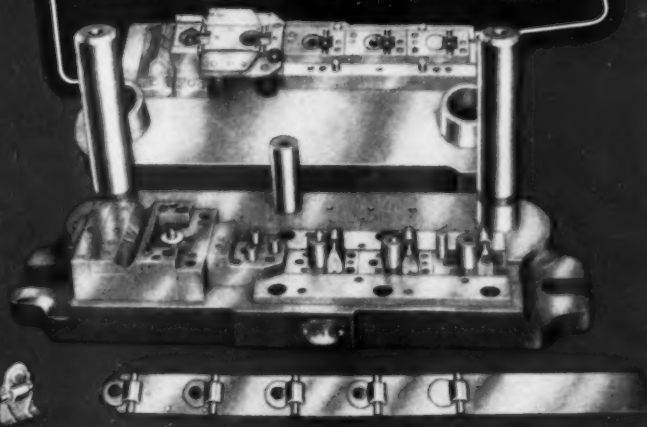
Graphite Electrodes, Anodes, Molds and Specialties

Sales office: Niagara Falls, N. Y. **Other offices:** New York, N. Y., Oak Park, Ill., Pittsburgh, Pa.

Sales Agents: J. B. Hayes, Birmingham, Ala.; George O'Hara, Long Beach, Cal.; Great Northern Carbon & Chemical Co., Ltd., Montreal, Canada

Overseas Carbon & Coke Company, Inc., Geneva, Switzerland; Great Eastern Carbon & Chemical Co., Inc., Chiyoda-Ku, Tokyo

Specialists in Die Materials for Industry



A COMPLETE LINE...CARBIDE AND STEEL

● Firth Sterling offers manufacturers and fabricators the advantages of a *single* source of supply of materials for both tungsten carbide and steel shaping, forming, piercing, heading and other dies. This *complete* line, from famous Firthalloy, for maximum performance where carbide is a requirement, through almost one hundred grades of high speed and tool steels for cut-off knives, roll guides, die casings, forming rolls and similar applications, provides the exactly right material for each application. Maximum production at lowest cost is thus assured.

Standard items are available from warehouse stocks; others may be obtained from your local tool and diemaker.

Firth Sterling representatives are skilled in interpreting the needs of industry and in suggesting the exactly right steel or carbide for specific applications. Because they know and sell both, you can depend on their unbiased recommendations to result in better, more economical tooling.

Firth Sterling

—INC—

GENERAL OFFICES: 3113 FORBES ST., PITTSBURGH 30, PA.

OFFICES AND WAREHOUSES*: BIRMINGHAM CHICAGO* CLEVELAND DAYTON DETROIT* HARTFORD* HOUSTON LOS ANGELES* NEW YORK PHILADELPHIA PITTSBURGH WASHINGTON WESTFIELD, N.J.

Attention:
Fastener Industry!
C.H.Q. Die Steel
makes
cold heading records



C.H.Q. solid die after 192,000 run.

A nationally known fastener manufacturer* recently made comparative tests of solid steel cold heading dies, under carefully controlled conditions, producing $\frac{3}{4}$ " square head machine bolts from 1020 steel on a Waterbury Farrel double stroke automatic.

Firth Sterling C.H.Q. came off with top honors and the highest production ever obtained by this manufacturer from any steel die . . . 192,045 both ends. (78,860 one end, 59 Rockwell C; 113,185 other end, 61 Rockwell C.) Standard competitive carbon steel dies produced only 50,000-60,000 both ends and ultimately failed by cracking axially. The C.H.Q. die wore oversize but longitudinally etched section revealed not even a hairline crack.

Ask for technical literature on C.H.Q.—or a Firth Sterling representative will discuss your die problems.

*(name on request)

PRODUCTS OF FIRTH STERLING METALLURGY

High Speed Steels	Sintered Tungsten Carbides
Tool & Die Steels	Firth Heavy Metal
Stainless Specialties	Chromium Carbides
High Temperature Alloys	High Temperature Cermet
Zirconium	



CHECK HARSHAW ON CENTRIFUGES

**Whether you are replacing a
worn-out unit or buying a new unit**

Centrifuges you order now can be shipped immediately from Harshaw Scientific stocks. Choose from the models listed below.

H-8500 International Clinical Centrifuge without head and tubes 115 V.A.C. **\$85.00**

H-8858 International Size 1, Model SBV, Centrifuge. Complete with reinforced welded steel guard, variable voltage auto transformer, tachometer, time switch, built-in sub-base 115 V.A.C. . . **\$590.00**

H-9506 International Size 2, Model V, Centrifuge, includes same equipment listed under H-8858, 115 V.A.C. **\$680.00**

H-9875 International Portable Refrigerated Centrifuge, Model PR-1, without heads or shields, 115 V.A.C. **\$1,895.00**

H-9901 International Chemical Centrifuge #450, with steel outerguard; without basket or draining chamber insert, 115 V.A.C. **\$130.00**

To avoid delay
send Harshaw your
order today!

A complete line of accessories for the above are carried in stock at all times. Many new accessories have been added. If in doubt, send for latest bulletins.

HARSHAW SCIENTIFIC
DIVISION OF THE HARSHAW CHEMICAL CO.
CLEVELAND 6, OHIO

Cleveland 6, Ohio
1945 East 97th St.
Cincinnati 13, Ohio
6265 Wiehe Road
Detroit 28, Mich.
9240 Hubbell Ave.



Houston 11, Texas
6622 Supply Row
Los Angeles 22, Calif.
3237 S. Garfield Ave.
Philadelphia 48, Pa.
Jackson & Swanson Sts.

Another use of



in modern transportation equipment

Autos are driven aboard the new Evans 6-Car Auto-Loader under their own power. Loading and unloading goes faster—shippers save time and money.



Gives Greater Strength with Lighter Weight to new Evans 6-car Auto-Loader

Evans Products Company, Plymouth, Michigan, chose N-A-X HIGH-TENSILE steel for major parts of its revolutionary new 6-Car Auto-Loader.

An outgrowth of the original Evans 4-Car loader, this new unit increases pay load by 50 per cent—enables two freight cars to do the work of three.

In designing the 6-Car Auto-Loader, Evans engineers specified N-A-X HIGH-TENSILE steel for all sheet, ramps, shear beams, and vertical members. This low-alloy steel has 50 per cent more strength than

mild carbon steel, with greater resistance to corrosion with either painted or unpainted surfaces. In tests carried out at the Evans plant, N-A-X HIGH-TENSILE steel scored high on engineering and impact tests. This new unit was designed with advisory assistance and cooperation from both the A.A.R. Car Construction Committee and the I.C.C.

You, too, can benefit from the many advantages of N-A-X HIGH-TENSILE steel to make your product stronger, lighter in weight, and longer-lasting.

GREAT LAKES STEEL CORPORATION

N-A-X ALLOY DIVISION

Ecorse, Detroit 29, Michigan

NATIONAL STEEL



CORPORATION



The crankshaft in the modern V-8 engine requires the ultimate in forging technique. Today's high compression engines, with continually increasing horsepower, further emphasize the importance of forging quality.

Wyman-Gordon technical know-how assures quality essential for maximum physical properties, uniform machinability and balance control . . . crankshaft forging specialists since the introduction of the internal combustion engine.

WYMAN-GORDON

Established 1883

FORGINGS OF ALUMINUM • MAGNESIUM • STEEL • TITANIUM

WORCESTER, MASSACHUSETTS

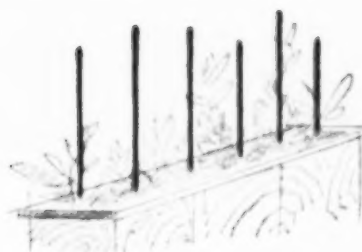
HARVEY, ILLINOIS

DETROIT, MICHIGAN

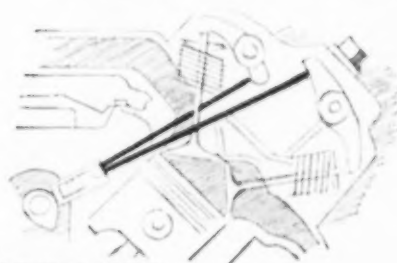
FROM *the Bundy Sketchbook*
TO *jog a designer's imagination*



**PARTS
FOR CHILD'S
STROLLER**



MODERN ROOM DIVIDERS

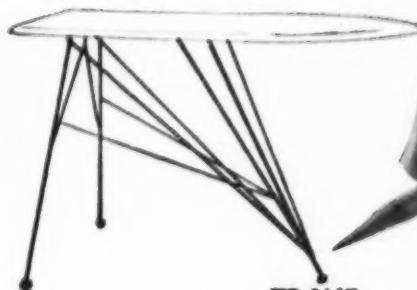


**PUSH RODS FOR
CAR-TRUCK ENGINES**

REMARKS The success (or failure) of that new tubing application hinges largely on the tubing you specify. Why not tip the scales in your favor by using strong, lightweight Bundyweld, the only tubing double-walled from a single metal strip. Added bonuses: Bundy's expert engineering assistance, unexcelled fabrication facilities.

WRITE today for catalog or for help in developing your tubing idea.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN



**FRAME
FOR IRONING BOARD**

WHY BUNDYWELD IS BETTER TUBING



Bundyweld starts as a single strip of copper-coated steel. Then it's...



continuously rolled twice around laterally into a tube of uniform thickness,



and passed through a furnace. Copper coating fuses with steel. Result...



SIZES UP TO 10" O.D.

Bundyweld, double-walled and brazed through 360° of wall contact.

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP

Leakproof
High thermal conductivity
High bursting point
High endurance limit
Extra-strong
Shock-resistant
Ductile

Lightweight
Machines easily
Takes plastic coating
Takes plating
Bright and clean
No inside bead
Uniform I.D., O.D.

Bundy Tubing Distributors and Representatives: Bridgeport, Conn.: Korhumi Steel & Aluminum Co., 117 E. Washington St. • Cambridge 42, Mass.: Austin-Hastings Co., Inc., 226 Binney St. • Chattanooga 2, Tenn.: Pearson-Deakins Co., 823-824 Chattanooga Bank Bldg. • Chicago 32, Ill.: Lapham-Hickey Co., 3333 W. 47th Place • Elizabeth, New Jersey: A. B. Murray Co., Inc., Post Office Box 476 • Los Angeles 58, Calif.: Tubesales, 5400 Alcoa Ave. • Philadelphia 3, Penn.: Rutan & Co., 1717 Sansom St. • San Francisco 10, Calif.: Pacific Metals Co., Ltd., 3100 19th St. • Seattle 4, Wash.: Eagle Metals Co., 4755 First Ave., South • Toronto 5, Ontario, Canada: Alloy Metal Sales, Ltd., 181 Fleet St., E. Bundyweld nickel and Monel tubing are sold by distributors of nickel and nickel alloys in principal cities.

Whips

the Radiant Tube Problem

Fabricated Inconel averages nine months' longer service in comparative tests of radiant W-tubes for roller hearth bright annealer

What life can you get from fabricated Inconel radiant tubes? The figures at the right speak for themselves. But here's a bit more on the service conditions.

The place: a large steel company. *The work:* bright annealing steel tubing. *The atmosphere:* slightly reducing. *The temperature:* 1725° (much higher in tube firing leg.) *The fabrication:* designed, formed and welded by Brown-Hutchinson Iron Works, Detroit 11, Michigan.

Perhaps Inconel would improve furnace equipment life in your plant, too. This high strength alloy is remarkably resistant to oxidation at high temperatures and to corrosive furnace atmospheres. It lends itself to a wide variety of designs and is readily fabricated.

To further explore Inconel's possibilities, write Inco for a copy of "Keep Costs Down — When Temperatures Go Up." It tells where, when, and why Inconel solves high temperature metal problems.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

REPORT ON LIFE OF "W"-TYPE RADIANT FIRING TUBES

Number of Tube	Location in Furnace	Wall Gage	Life Record of Previous Tube	INCONEL	Condition at End of Test
1	No. 2 Furnace N.S. No. 5, Top	.125	24 months	38 months	Still OK
2	No. 2 Furnace N.S. No. 6, Top	.095	10 months	Failed after 36 months	Removed
3	No. 4 Furnace S.S. No. 9, Top	.125	20 months	38 months	Still OK
4	No. 4 Furnace N.S. No. 5, Top	.125	25 months	33 months	Still OK
5	No. 4 Furnace N.S. No. 7, Top	.095	26 months	Accidentally damaged at 11th month	Scrapped
6	No. 4 Furnace S.S. No. 10, Top	.125	29 months	31 months	Still OK
7	No. 4 Furnace N.S. No. 6, Top	.125	23 months	Failed after 31 months	Removed

Inconel



Incoloy



Nickel Alloys

... for long life at high temperatures

A prize recipe for brazing spuds



The principal ingredient is the low-temperature silver brazing alloy EASY-FLO. You simply place the spud in position with a ring of EASY-FLO wire around it, apply flux and heat. Logan Machine & Metal Stamping Co., Akron, Ohio, get excellent results with this recipe in brazing spuds in the oil pans that are part of an automatic automobile drive. Photos show how they do it.

Pans with spuds and EASY-FLO rings are placed in fixtures of 2-station induction heating unit. Brazing two at a time, production is 400 an hour. Under a 100-lb. torque test "the pan pulls apart first."



GET THIS METAL JOINING RECIPE BOOK...

It gives you tried and proved recipes for fast, low-cost metal joining that never fail. Write for a copy today. Ask for BULLETIN 20.



HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

DISTRIBUTORS IN PRINCIPAL CITIES

OFFICES and PLANTS
BRIDGEPORT, CONN.
PROVIDENCE, R. I.
CHICAGO, ILL.
CLEVELAND, OHIO
DETROIT, MICH.
LOS ANGELES, CALIF.
TORONTO, CANADA
MONTREAL, CANADA

Fast, Accurate Testing

with an

OLSEN Super "L"

Olsen Super "L"
U.T.M. used by
Douglas Aircraft
Company, Inc.
El Segundo, Calif.
Division for
testing aircraft
materials.



Featuring the incomparable SelecRange electronic indicating system, Olsen Super "L" Universal Testing Machines are used in leading testing laboratories throughout the country for fast, accurate tension, compression and flexure testing of materials of every description.

Only the Olsen SelecRange Indicating System provides 50 to 1 spread of testing ranges; instant change of ranges during test with the flip of a switch, without compensations of any kind; and many other important features that have literally revolutionized testing.

Electric extensometers used in conjunction with the Model 51 Electronic Recorder produce stress-strain curves with the Super "L". In addition, the 120,000 lb. capacity machine illustrated has a Crosshead Rate Indicator, mounted on the left of the control cabinet, which instantly shows the rate of crosshead movement in inches per minute on an electrical meter.

From every angle, the testing speed, ease of operation, and versatility of the Olsen Super "L" mean greater testing efficiency at remarkably low cost.

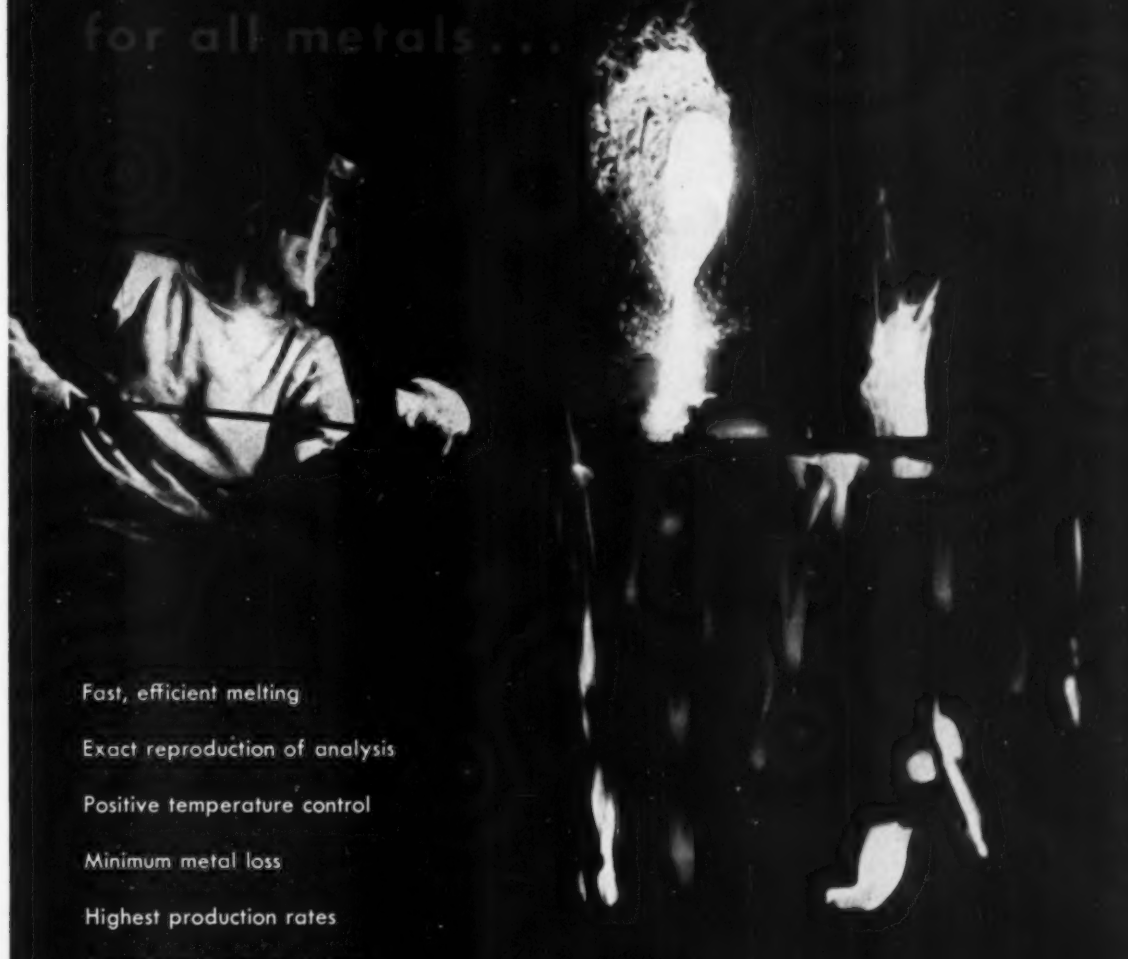
Details are given in Bulletin 47. Write for your copy today.

TINIUS  OLSEN
Testing & Balancing Machines

TINIUS OLSEN
TESTING MACHINE CO.
2030 Easton Road - Willow Grove, Pa.

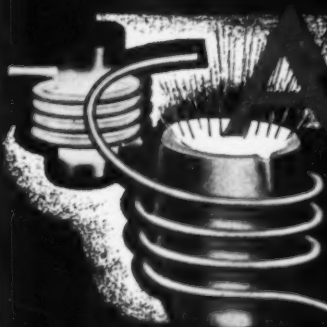
THE IDEAL METHOD:

INDUCTION MELTING for all metals...



- Fast, efficient melting
- Exact reproduction of analysis
- Positive temperature control
- Minimum metal loss
- Highest production rates
- Sizes from 8 ozs. to 8 tons

Write for information



NORTHROP

SINCE 1916

INDUCTION HEATING-MELTING

AJAX ELECTROTHERMIC CORPORATION • TRENTON 5, NEW JERSEY

546

ASSOCIATED COMPANIES: AJAX ELECTRIC FURNACE CORPORATION • AJAX ELECTRIC COMPANY • AJAX ENGINEERING CORPORATION

new RYCUT

LEADED FREE-MACHINING ALLOY STEEL

ups production

25% to 200%

It's the lead—finely dispersed throughout the steel—that makes Rycut the best series of alloy steels for overall machinability.

(Faster machinability)—The lead addition provides alloy steels with the machinability of free machining carbon steels. Tools run cooler, stay sharper, last as much as 300% longer. And, because tools stay sharp longer, closer tolerances are obtained, with lowered tool costs. Customers report production increases as high as 200% over comparable standard AISI analyses.

(Mechanical properties unaffected)—The addition of lead has no known effect on the mechanical properties of Rycut alloys nor response to heat treatment. Hardenability falls within the same range as corresponding AISI analyses. Rycut, particularly in the heat treated condition, shows its superior machinability over standard heat treated alloys.

The lead in Rycut reduces the co-efficient of friction on turning 10% to 15%. With less drag

on the tool and less tendency to wear, a smoother, brighter finish is obtained. Rycut alloys produce a better finish at higher speeds than AISI analyses.

So, for better quality parts, machined faster with fewer rejects, use Rycut alloys. To get further information on these great new cost-cutting steels—or to order test quantities—call or write Ryerson now. Bulletin 14-5 on request.

The Rycut Series

Rycut 20	—.20 Carbon, Leaded Alloy Steel
Rycut 40	—.40 Carbon, Leaded Alloy Steel
New Rycut 50	—.50 Carbon, Leaded Alloy Steel
Rycut 47	—.47 Carbon, Leaded Alloy Steel*

*In Eastern Plant

LEADED CARBON STEELS

We also have complete stocks of Ledloy—the amazingly fast cutting, open hearth steel. See Ryerson Stock List or write for bulletin.



RYERSON STEEL

Principal products: Bars, structurals, plates, sheets and strip, mechanical tubing and boiler tubes, alloy and stainless steel, reinforcing bars, machinery & tools, etc.

JOSEPH T. RYERSON & SON, INC. PLANTS AT: NEW YORK • BOSTON • PHILADELPHIA • CHARLOTTE, N. C. • CINCINNATI • CLEVELAND
DETROIT • PITTSBURGH • BUFFALO • CHICAGO • MILWAUKEE • ST. LOUIS • LOS ANGELES • SAN FRANCISCO • SPOKANE • SEATTLE

Metal Progress


Volume 66, No. 3


September, 1954

Critical Points ...

BY THE
EDITOR ...

Toolsteel Mill in Canada


Flew recently from Cleveland to London (Ontario, just across Lake Erie) to join many friends of Vanadium-Alloys Steel Co. in the opening of a Canadian subsidiary, thus becoming Atlas Steel Ltd. of Welland's competitor in the tool and die steel business up north. James P. Gill, president of the steel company and past-president of , said that ingots could be imported duty free from the home plant in Latrobe, Pa., whereas finished bars carried a 12¢ duty. Thus it is economical to install modern heating furnaces, hammers, presses, rolling mills and the usual straightening and finishing machinery and convert ingots to bars on the Canadian side.

Duty-free ingot is a sensible arrangement for the Canadians, who can only let the Americans find the necessary high-grade raw materials and scarce alloying elements. George Roberts, vice-president (both of the steel company and of ) also said that the Canadian staff—nearly all recruited locally—would be spared the big headaches in the business which reside in the melting department, and arise from the necessity of producing small amounts of special analyses and of highest uniformity and quality.

The toolsteel business in America is scattered among many small plants principally because of the "job-lot" nature of the business. Strong com-


petition prevents any decree that high speed steel shall be 18-4-1, take it or leave it. Even this well-standardized analysis is produced on occasion in $\pm 0.02\%$ carbon ranges; Roberts said that five Vanadium-Alloys' customers regularly make large purchases ("large" in the toolsteel trade) of rounds for $\frac{1}{2}$ -in. twist drills—almost a Sears-Roebuck item—yet no two of them specify the same diameter!

Some metallurgical items of interest were also uncovered during inspection of the London plant. Ingots of high speed toolsteel are small, 10 in. square on top; 9 in. on bottom, 20 in. high. They are cast on copper stools; taper-walled molds are thick at bottom, quite thin at top; thus solidification starts promptly at bottom, and is delayed at top. Shrinkage is fed by a rather unique refractory hot top, a 12-in. cube, placed on each mold immediately before pouring, and so hot it is almost plastic. The pouring gate in the center is conical, 4 in. diameter at bottom and 7 in. at top. An exothermic compound is placed on the molten metal immediately after the ingot is teemed, and remains so fluid that its top surface is flat at the end. This conical projection is easily broken off the ingot and the fracture tells the skilled melter a good deal about the quality of each ingot. Hot top discard also is less than 5%.

L. D. Bowman, , vice-president for operations, said that an advantage of hammers and presses ordinarily used in toolsteel mills rather

than blooming mills (other than their lower capital charges) is that the expert hammerman is able to observe any early tendency for corner cracks or top and bottom defects and take proper steps immediately to prevent their spread. Thus the yield of marketable metal is considerably higher if the ingots are forged rather than bloomed. There is more loss from scale in a hammer department, but this does not eat up the gains from the other factors. The hammer or press also breaks up and distributes carbide grain boundaries more effectively in the high-carbon steels when the amount of reduction from ingot to die block is moderate.

A New Steel for Pressure Vessels

Now-a-days it evidently is not enough for the boys in the metallurgical department to devise a heat treated, low-alloy steel, with excellent weldability without preheat or stress relief, good impact strength, ductility and bendability in all directions, low temperature of transition from ductile to brittle type of fracture, and various other qualifications and examinations numbering 77 in all – it is not enough to devise the steel, but convince the manufacturing department that it can be made and heat treated in existing equipment, and the sales department that it can be sold at the necessary price. After the U.S. Steel Corp.'s technical staff was able to do all this, the experience of the Chicago Bridge & Iron Co. with welded pressure vessels was enlisted and some cylinders were designed, constructed of the new alloy, and tested, to prove the hopes of the promoters. Finally, in a two-day program staged at Birmingham, Ala., for some 300 metals engineers from all over the United States, four tanks were tested to destruction while their death throes were recorded by batteries of movie cameras, thermocouples, and strain gages. Leon S. Bibber, , welding research engineer who was responsible (he "headed task-force for Operation T-1", to adopt the official *cliche*) doubtless heaved a sigh of relief at the end, not that he had much doubt that the pressure vessels would perform nobly, but that some of the human or electronic observers might get into trouble, despite his best laid plans.

The less colorful metallurgical details can be listed as follows: The steel is dubbed "Carilloy T-1" – "U.S.S. Carilloy" being a trade name used by the Corporation for 15 years for the conventional and special alloy steels produced by the

subsidiary then known as Carnegie-Illinois Steel Corp. In the Corporation's trade literature, the usual chromium-molybdenum analyses were recommended for pressure vessels operating at high temperatures, and 2315 (0.50 Mn, 3.50 Ni) for low temperatures. Much Grade B Firebox steel, plain carbon steel corresponding to A.S.T.M. specifications A 201 and A 212, has also been used in the past. The new "Carilloy T-1" resembles the triple-alloy steels developed during war time, but with other elements added for this or that (0.15 C, 1.00 Mn, 0.90 Ni, 0.50 Cr, 0.50 Mo, 0.35 Cu, 0.05 V, boron and aluminum treated), and is heat treated at the mill by water quenching from 1650° and long tempering at 1200° F. It has exceptional freedom from directional properties, a yield strength (load for 0.2% elongation) over 90,000 psi., good ductility, Charpy keyhole impact over 15 ft.-lb. at 70° F., transition from ductile to brittle fracture below –150° F.

The four tanks tested were made of ½-in. plate, 4-ft. diameter, 20-ft. length, with ends of five spherical segments. Two tanks were stress-relieved, two not. All the Birmingham tests were made while the tanks were at –35 to –50° F. and full of refrigerated brine. Two were cracked by internal pressure at 2850 psi. pressure and nominal stresses of 135,000 psi. (somewhat above the ultimate strength of test pieces cut from the original plate). The other two were supported near the ends, pumped up to 1875-psi. internal pressure, and a saddle mid-length hit by a 13-ton ingot falling successively from 50, 75 and 100 ft. They cracked only after the last drop.

E. C. Wright, *Metal Progress's* consulting editor who was present, writes that "a striking feature of both the bursting and drop tests was that every bit of the fracture was of the ductile shear type, and there was no evidence whatever of brittle fracture" under the conditions of extreme cold, high multi-axial stress, and impact – conditions which Professor Shank says, in his article immediately following, have been associated with catastrophic failures with brittle fracture.


As to cost: At the mill it will be about 2½ times that of firebox steel. If the Codes can be revised to permit the designers to use one half the minimum yield stress of the new alloy steel ($0.5 \times 90,000$ or 45,000 psi.) as the tests indicate will be safe, instead of one quarter of the ultimate strength ($0.25 \times 70,000$ or 17,500 psi. now permissible for carbon steel) then the amount of steel, welding and other cost elements going into a given pressure vessel will be so much lower that notable savings can be demonstrated. 



Fig. 1—Fragment of a Fractured Drum. Note shiny, faceted appearance, sometimes called the chevron pattern. Apices of herringbone markings point to the origin of failure

Brittle Failure of Steel Structures —a Brief History

*By M. E. SHANK**

Although 250 welded ships have been disabled since 1940 by brittle cracking, such failures began as soon as steel plate became available for structural use and include storage tanks, bridges, booms and long pipe lines.

DURING World War II the problem of brittle failure received sudden prominence with the breaking up at sea and at dockside of welded steel merchant vessels, especially Liberty Ships and T-2 tankers. For this reason, in the minds of some persons, the problem of brittle failure is associated mainly with ships. However, a study of other steel plate structures shows that brittle failure is a general engineering problem, not

confined to ships nor any other single category.

Neither is the problem a new one. In 1856, Bessemer announced his process of steelmaking, and shortly thereafter steel became available in comparatively large quantities. A few years later (1861), openhearth steel became available. Formerly, steel had been made by carburizing wrought iron; it was scarce and expensive; therefore, it was limited to such uses as cutlery and

*Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

This paper is based, in part, on a report to the Committee on Ship Structural Design of the National Academy of Sciences, National Research Council. The Committee on Ship Structural Design is advisory

to the interagency Ship Structure Committee which supported this investigation as part of its research program.

The complete report, "A Critical Survey of Brittle Failure in Carbon Plate Steel Structures Other Than Ships", was published as Report SSC 65 by the Ship Structure Committee, U. S. Coast Guard

Headquarters, Washington 25, D. C. It is also available as Bulletin No. 17 of the Welding Research Council.

The opinions expressed in this article are those of the author and do not necessarily represent the views of the Committee on Ship Structural Design or the Ship Structure Committee.

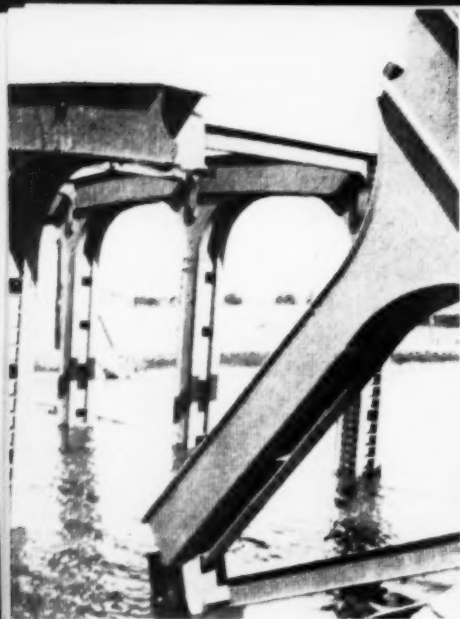


Fig. 2—Hasselt Bridge in Belgium. Note extreme brittleness of breaks (*Metal Progress*, May 1939, P. 492)



Fig. 3—T-2 Tanker Which Broke in Half at Dockside

springs. Wrought iron and cast iron were the structural materials. In Great Britain, Board of Trade regulations prohibited the use of steel in construction, and their revision in 1877 provided a great stimulus to the steel industry in that country. Thus, during the period of 1860 to 1890, both in Europe and the United States, wrought iron was gradually being supplanted as a structural metal by steel. Reluctance by engineers to discard the old reliable wrought iron caused the change to come about slowly, but in the long run, the cheapness, greater availability, and superior strength of steel won out. As more steel came into use, troubles with brittle failure began to appear.

In the *Journal* of the Iron and Steel Institute for 1879 appears a paper by Nathaniel Barnaby on "The Use of Steel in Naval Construction". Mr. Barnaby deploras: "Recent cases have occurred of fracture in bessemer bars . . . from some trifling blow or strain . . . they nearly all took place during the late severe weather at Chatham."

In the ensuing discussion of the paper, Mr. Barnaby was roundly denounced by the assemblage. However, in that same meeting one Mr. Kirk complains of the cracking of steel in a mysterious manner. In particular, he cites a steel plate which "when cold, on being thrown down, split right up. Pieces cut from each side of the split stood all the Admiralty tests. Now given a material capable of standing without break-

ing an extension of 20% he wanted to know . . . how a plate . . . could split with a very slight extension . . . not to the extent of 1%."

Mr. Kirk thereupon asked the steelmakers for a remedy to this problem, and, if a remedy was not available, at least a rational explanation. His question was totally ignored. Today the problem is yet with us, and modern engineers and metallurgists are still striving to satisfy Mr. Kirk's request of 75 years ago.

It might be well to summarize briefly the manifestations of brittle fracture occurring in carbon steel plate.

Three conditions may combine to bring about such failures: First is low temperature—say $+40^{\circ}\text{F.}$ to -40°F. , such as exists in the ambient atmosphere. Second is the presence of a notch (introducing triaxial stress); any defect such as a welding crack or a void, or a crack left by a punching or shearing operation can serve as a notch which will initiate brittle failure, and so it is sometimes called "notch brittleness". The third factor is high strain rate, but such impact loading is not necessary for brittle failures; as will be shown, many have been initiated under what appear to be completely static conditions.

When brittle failure occurs, it may be recognized by several earmarks. Among these are the speed at which fracture occurs (approaching several thousand feet per second), almost complete lack of ductility, negligible energy absorption, and a "brittle" or faceted appearance of the

fractured surface. Moreover, the fractured surface often has a characteristic "chevron" or "herringbone" appearance, the apices of the herringbones pointing to the origin of the fracture, an extreme example of which is shown in Fig. 1. Finally, when steel plate taken from a structure which failed in a completely brittle manner is tested in an ordinary tension test, it manifests a high degree of ductility and strength! It is this last characteristic which was so baffling to engineers.

Failures of Riveted Structures

Steel plate was customarily joined by rivets, of course, up to about 30 years ago. The earliest structural brittle failure on record, apparently, is a riveted water standpipe at Gravesend, Long Island, in 1886. It was an ambitious design, 250 ft. high, 16 ft. in diameter up to a height of 59 ft., decreasing conically in a length of 25 ft. to an 8-ft. diameter, which was retained to the top. The whole was steadied by guy wires. Plates in two sizes, 5x7 ft. and 5x9 ft., were employed with thicknesses varying from 1 in. at the bottom to $\frac{1}{2}$ in. at the top. All joints were triple riveted. Failure occurred during the hydrostatic acceptance test. Water had been pumped to a height of 227 ft. when there was a sharp rending sound; a vertical crack appeared in the bottom, running up about 20 ft. The whole tower then collapsed. An eye-witness noted that the workmanship seemed to be good, that some of the upper plates were tough and ductile, having actually rolled up, while others in the bottom of the tower were brittle with glass-like fractures. He concluded that only a brittle material could have wrought the destruction that occurred, and that it seemed as if all this defective plate had been concentrated in the lower part of the tower.

From 1898 up through 1933 engineering publications contain occasional accounts of brittle failures of riveted water tanks, gas holders, oil storage tanks, and ships. However, since 1900 over a dozen riveted merchant ships have broken in two or are listed as missing. It may be significant that most of these vessels were of the tanker type (the same category that has given the most trouble in welded ships) but such famous passenger liners as the *Leviathan* and the *Majestic* experienced cracks in their upper strength decks. These cracks started in square openings and sometimes extended to the shell—some even extended down the shell. In at least one case a loud report accompanied the forma-



Fig. 4—Failed Spherical Pressure Vessel at Morgantown, W. Va., Showing Long Brittle Tear

Fig. 5—Failed Power Shovel Boom. The end of the boom (pressed plate) has broken off



tion of a crack, indicating brittle fracture. The Europa had similar cracks.

The most famous brittle failure of a riveted structure was a molasses tank in Boston. One January day in 1919, when the tank contained 2,300,000 gal. of molasses, it burst open. Twelve persons were drowned in molasses or died of injuries; 40 others were injured. Houses in the path of the flood were damaged and a portion of the Boston Elevated Railway knocked over. An extensive lawsuit followed, and many well-known engineers and scientists were called to testify. Much conflicting testimony was presented as to the cause, and it was here that the significance of the chevron pattern in a service failure (see Fig. 1) was recognized.

Finally after years of testimony, the court-appointed auditor decided that the tank failed by overstress. In comment he said: "... Amid this swirl of polemical scientific waters it is not strange that the auditor has at times felt that the only rock to which he could safely cling was the obvious fact that at least one-half of the scientists must be wrong. . . .". This statement fairly well summarized the engineering knowledge (or lack of it) concerning notch-brittle behavior.

Failures of Welded Structures

Bridges—Just prior to World War II, about 50 bridges of a type known as a Vierendeel truss were built across the Albert Canal in Belgium. They possessed straight lower chords and curved upper chords, joined by verticals. There were no diagonals, yet the structure was a very rigid one. Some of these bridges were built of welded or rolled I-beam and plate, others entirely of plate. The span and detail were varied to suit the location. In March 1938 when the weather was quite cold the bridge at Hasselt, with a span of 245 ft., collapsed into the canal (Fig. 2). Eyewitnesses heard a sound like a shot and saw a crack open in the lower chord. This left the top chord acting as an arch. Six minutes later the bridge broke into three pieces, and fell into the canal. All the fractures were brittle, some through welds, others in solid plate away from the welds. The bridge was lightly loaded at the time. Within two years, two similar bridges failed in the same way.

These failures set off a great flurry in engineering circles. Numerous references to them, and to the supposed cause, were made by foreign correspondents to *Metal Progress*. The Belgium-Luxembourg steel industry claimed that the quality of the steel was above reproach, and the

failure of the Hasselt bridge was due to poor welds. Representatives of the welding industry had also visited the site and satisfied themselves that the failure was not due to the weakness or imperfection of the welded joints.

Both judgments were premature. Several years later a thorough investigation was undertaken by two Germans, H. Busch and W. Reuleke. They reported that most failures were initiated at welds, and that many welds were defective. They found that on Charpy notch-impact tests practically all specimens were brittle (at least in part) at the cold temperature which existed at the time of failure. Their conclusions stated that the accident was caused by (a) multiaxial restraint and residual stress, (b) low ambient temperature, (c) low notch-impact characteristics of the steel. They seriously questioned whether nonkilled bessemer steel should be used in thick plate, despite good static-tension properties, since its notch-impact is low.

The Vierendeel bridge failures were a prelude to the brittle ship failures which occurred in World War II. Between 1942 and 1952 about 250 welded ships suffered one or more brittle fractures of such severity that the vessels were lost or were in a dangerous condition. Nineteen of these 250 ships broke completely in two or were abandoned after their backs were broken; 11 were tankers, 7 were Liberty Ships for dry cargo. In the same 10-year period, 1200 welded ships suffered brittle cracks, generally less than 10 ft. in length, which did not disable the ships but were potentially dangerous. The foregoing figures are for ships over 350 ft. long; very few failures have occurred in smaller vessels.

Ships—The first welded ship failure was that of a T-2 tanker in January 1943. While the vessel was sitting quietly at her fitting-out pier in Portland, Ore., the deck and sides fractured amidship with a report heard for at least a mile. The vessel, held together only by its bottom plating, jack-knifed so the center rose out of the water. See Fig. 3.

In Liberty Ships, the majority of the failures started at square hatch corners and square cut-outs in the top of the "sheer strake"—that is, the highest strip of shell plating. The frequency of serious failures was reduced after structural details, such as hatch corners, were redesigned. In addition, riveted straps or crack arresters—similar to butt straps in riveted plate work—were installed in the deck and at the gunwales, and all plate welds terminated in a slot behind these crack arresters.

In the T-2 tankers, most failures initiated in defects at butt welds in the hull. No simple remedial measures were possible, but finally four or more crack arresters were installed on these tankers, two on the deck and two in the bottom. It is to be noted, however, that crack arresters, while limiting the *extent* of cracks, do not *prevent* their occurrence, and so the frequency of serious fractures in T-2 tankers did not markedly diminish. A recent directive of the American Bureau of Shipping calls for installation of additional crack arresters in these ships, as well as strengthening the hull girder.

Pressure Vessels—Brittle failures of pressure vessels have occurred in recent years. One of these occurred in Schenectady, N. Y., in February 1943. The vessel was a spherical hydrogen tank of welded construction, 38.5 ft. in diameter, with 0.66-in. wall of semikilled plate. It had been in service three months. The design was in accordance with Paragraph U-69 of the A.S.M.E. Code for Unfired Pressure Vessels. The design called for a working pressure of 50 psi., a working stress of 11,000 psi., and a weld efficiency of 80%. In 1942 it had been tested at 62.5 psi. and showed no leaks. The manhole of the tank had been made in two subassemblies (bolt flange of neck in one, collar and sphere plate in the other) and had been field welded in place. All manhole plates were made of $\frac{3}{4}$ -in. sheared cold rolled plate. The plates were dished cold, and in accordance with Paragraph U-69 of the code, not stress-relieved.

On the day of the fracture the ambient temperature had been below zero, had risen 27° F. in 7 hr., and was 10° F. when failure occurred. The internal pressure was about 50 psi. The sphere burst catastrophically into 20 fragments, with a total of 650 ft. of herringboned brittle tears. The tears were plotted on a model, with directions of herringbones marked by arrows. All herringbones led back to the manhole, which was the origin of fracture. The intensity of the failure was greatest in the manhole region.

The general quality of the welding was excellent. Only a few feet of fracture followed welded seams or the heat-affected zones alongside. Later examination of the relief valves showed them to be operating satisfactorily. Except in a minor way, fractures did not involve support-leg attachments where stresses were high. On good evidence the possibility of internal explosion was eliminated. The field assembly of the manhole neck required heavy welds of many passes, and old cracks were found, as well as many small



Fig. 6 — Failed Gas Line, 30 In. Diameter, Showing Sinusoidal Nature of Fracture. Note longitudinal welded seam, which appears to be intact. Presumably this failure occurred while installation was being tested. (Courtesy Lincoln Electric Co.)

cracks in the inner, sheared edge of the neck.

The investigators believed the causes to be:

1. High stresses at the manhole neck resulting from the presence of the hole in the sphere.
2. Residual stresses approaching the yield point in the manhole neck due to shrinkage of the heavy welds; there were several old radial cracks in this region.
3. The use of semikilled steel, which was brittle under the existing circumstances.
4. Probably thermal "shock" due to the rapid rise of temperature which increased the hydrogen pressure, or to thermal stress resulting from uneven heating by the sun's rays. The large amount of energy available from the compressed gas was sufficient to scatter the pieces without an explosion.

The investigators recommended that gas vessels should be tested at twice the working pressure with water, rather than 1½ times the working pressure with gas, and that subassemblies (such as manholes and nozzles) should be built in the shop, stress-relieved, and Magnafluxed for cracks, and designed to avoid heavy, built-up weld deposits which cause high residual stress.

Other spherical pressure-vessel failures occurred in Pennsylvania in March 1943 during a test, and at Morgantown, W. Va. (Fig. 4) in January 1944, also on test. In Cleveland, extremely disastrous failures occurred in a cylindrical and in a spherical gas pressure vessel in October 1944. These two vessels, built of a 3½% nickel steel, had been used to store liquefied

natural gas at a pressure of 5 psi. gage and -260° F. Burning liquid got into the storm sewers and fire spread into several blocks of residences nearby. In the ensuing holocaust 128 persons were killed, and damage amounting to \$6,800,000 resulted.*

Other Structures—Failure of power-shovel booms and dipper sticks (the member which carries the bucket) have been reported. Most of these occurred in cold weather, at -15 to -20° F. Figure 5 shows a power shovel on which the end of the boom has broken off. The material was a "Man-Ten" plate, containing 1.25 to 1.70% manganese, usually classified as a low-alloy steel.

Similarly, the brittle failures of oil-storage tanks, a smokestack, and a penstock have been reported. Three new oil-storage tanks broke up before they had ever been filled. The weld overflow on the seams inside the tank had been chipped flush during erection, leaving tiny notches. Following a sharp temperature drop, long cracks appeared across the welds, entering the plates on either side.

Pipe Lines—In the period since 1948 failures have occurred in high-pressure gas transmission pipe lines. Pipe for these cross-country lines is now usually produced according to an American Petroleum Institute standard, which specifies grades of strengths. Comparatively high values of carbon (0.34% max.) and manganese (1.30% max.) are allowed. In one method of manufacture the pipe is cold formed, seam-welded, and hydrostatically cold expanded, both to round it and to boost its yield strength up to the value specified. It is then hydrostatically tested. Raising of the yield by cold work has an important economic consequence. Inasmuch as a thinner pipe wall can thus be used, a considerable weight of steel can be eliminated. Large savings result.

Installation methods and allowable pressure in transmission lines are covered by an American Standards Association code (now being revised). Under this code it is permissible, in sparsely populated areas, to carry a pressure (approximately 800 psi.) which will stress the pipe to 72% of its yield strength. In more densely populated areas stresses from pressure are limited to about 50% of yield strength.

There is little published information concerning failures in gas-transmission-lines. One short

article says they range from 180 to 3200 ft. in length. (The failures here described occurred on test, after installation.) The cause—presumably the initiating cause—is stated to be well known, namely, gouging or scratching of the plate in transit or installation. The failures always follow a sine wave pattern and look as though there had been an internal explosion. See Fig. 6.

In addition, a report of the Federal Power Commission lists a number of "splits" of pipe which occurred on test and in service. These splits were in the pipe itself, not in the weld. Details about these accidents are unobtainable—indeed, many of the data were probably lost in subsequent repair and replacement. It seems probable that some of these splits represented brittle breaks, but that others did not.

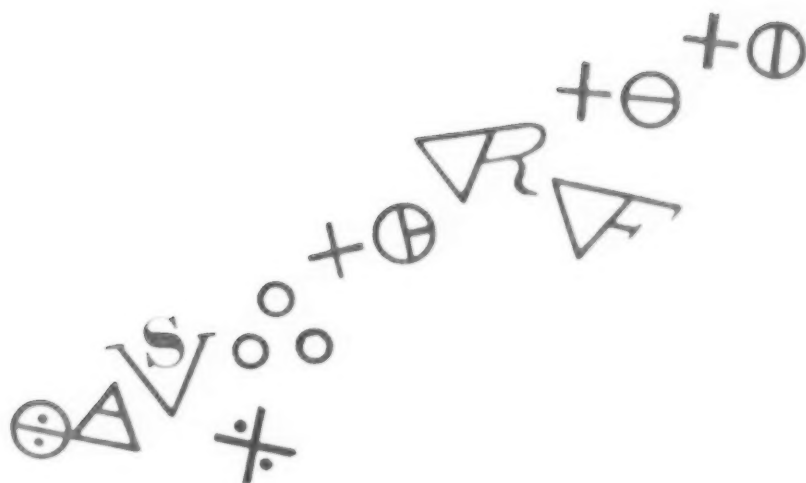
Because detailed technical information is lacking, definite statements about brittle pipe-line failures are difficult. However, some interesting speculations can be ventured. One speculation concerns field welding to join sections of pipe. With the upper limits of carbon and manganese contents allowed in the steel under A.P.I. Standard 5LX, trouble may be encountered in field welding of girth joints, since air hardening and subsequent cracking might occur in the heat-affected zone.

Another speculation concerns the rate of crack propagation in steel versus the rate of pressure released in natural gas (methane) following a pipe break. The gas pressure will be released by an elastic wave traveling at the speed of sound, approximately 1300 ft. per sec., and this rate will not be affected by pressure. Experimental values of 2750 to 6600 ft. per sec. have been measured in brittle fracture of steel in the laboratory. Thus it appears that the gas-discharge pressure wave will never catch up with the brittle crack; the tip of the crack is always traveling in a stressed area. This would account for the long breaks described. Testing of pipe lines with water might prevent such long breaks, inasmuch as the velocity of an elastic wave in water is about 4800 ft. per sec.

To determine this and other unknown factors the gas industry is sponsoring a considerable amount of research on the complex problem of brittle failure. ☐

*This disaster was extensively studied, and the report of the Mayor's Commission is on file in the Cleveland Public Library. Reports of investigations sponsored by the East Ohio Gas Co. and by the U.S. Bureau of Mines are also available on request.

EDITOR'S FOOTNOTE — This brief article about the history of brittle fractures in notable structures will be followed by others discussing the factors of importance in such failures, the probable mechanisms of crack propagation, and the possible solutions.



Metallurgy

in the Days of Alchemy

By CARL ANDREW ZAPFFE*

In "Light Metallurgy" in last November's issue, R. P. Lister suggested that alchemical gibberish was due to contrasting urges — the scientist's urge to publish and the industrialist's urge to secrecy.

Carl Zapffe now shows that alchemical symbols were in common use in 1776, and some of the "principles" were not so erroneous.

For example, change "phlogiston" to "energy" and that theory makes sense to physical chemists.

DURING the reign of Ptolemy Philadelphus in Egypt (285 to 247 B.C.), the Pharos of Alexandria was built by Sostratus of Cnidus. This was the father of lighthouses and one of the Seven Wonders of the World. Built of white marble blocks bonded with cast lead, it stood approximately 600 ft. high and contained some 300 rooms. An immense mirror capped the structure, mounted upon trunnions such that it could be turned to focus the sun's rays upon enemy

ships—allegedly being able to set them on fire at distances up to 100 miles.

According to later Arab tradition, this Pharos was built upon a foundation of glass, and the means of its selection strikes a familiar note for the modern student of corrosion familiar with Kure Beach in North Carolina, the extensive marine corrosion station. Thus, Sostratus immersed "stone, brick, granite, gold, silver, copper,

*Metallurgist, Baltimore, Md.

lead, iron, glass, and all kinds of minerals in the sea to test them. When they were taken out and examined the glass alone was found full of weight and unimpaired."

So glass was chosen—in great blocks!

Organization of Alchemy—Such descriptions of ancient works and monuments* are useful in reminding one that ingenuity and intellect have long been attributes of the human race. Modern science is primarily the product of a state of organized thought, rather than a special acquisition from mental powers lacking in our predecessors, and metaphysics and alchemy represent its prior or preliminary stages.

In turn, their origins are as old as recorded history, first taking outline as an occult cosmology within a web of religion by the almost legendary figure of Hermes Trismegistus in ancient Egypt. Then in the 4th Century B. C. Aristotle founded a logic for physics and metaphysics simultaneously, established the Peripatetic School in Greece, and laid the headstone for occidental intellectualism. It was Aristotle's special ward, Alexander of Macedon, who in the brief span of 13 years, and before he was 33 years of age, spread Aristotelian philosophy across the lands he conquered from Libya in Africa to the Hindu Kush, and who built the city of Alexandria in Egypt where the Pharos was erected half a century later. The entire status of civilization became altered, largely pivoting thereafter upon the libraries and schools of Alexandria.

When this center of world learning was destroyed in the declining years of the Roman Empire, Arabian scientists and philosophers such as Geber and Avicenna kept the intellectual light burning until Copernicus, Galileo, Newton, and their contemporaries completed the bridge to modern science. The writings of Copernicus remained laden with astrology and metaphysics; and as recently as the time of our own Revolutionary War, as will shortly be described in detail, chemistry and metallurgy were still being described in terms of alchemical symbols.

Strictly speaking, alchemy itself is but a structural unit standing within this broad historical edifice. It was not until several centuries of the Christian Era had elapsed that transmutation—the identifying element of alchemy—appeared on the scene, and not till after the first millen-

nium was there much in the written record. While this is no place to enter into the involved and continuing discussions on alchemical interpretation, we should recognize the impact of Christian philosophy upon the two streams of physical and metaphysical thought mentioned above. Influenced by the religious concept of Christ's resurrection, both physical and metaphysical thought acquired hypotheses about transmutation from lower to higher forms, from impure to pure. For the metaphysical branch, discussions remained esoteric and confined to spiritual processes taking place within man; in the physical branch (probably for the very reason of the ancient entwinement of science and religion) the students pursued an esoteric but parallel course which attempted to force upon the natural elements those transmutations symbolized in spiritual discussions by lead, silver, gold, and so forth. Whether transmutation was ever accomplished physically remains a matter of warm dispute. That physical transmutation is an inherent possibility of the natural order is now *mirabile dictu* an established fact. The only feature of present concern, however, is that this physical branch—alchemy—is the one that eventually spawned the scientific era, and the latter sharply separated itself from the metaphysical stream and from the entire parent element of religion.

The General Alchemical Concept

In order to extract some information from the accompanying tabulations, some principal features of the alchemical viewpoint must first be outlined. Primary consideration was usually given to the *principle*, or the essential quality of a body or a phenomenon, rather than to its physical measurements—that is to say, to solidity and liquidity rather than to solids and liquids. Thus, the three states of matter (or their *principles*) as we know them today were designated earth, water, and air in the Aristotelian system, with fire added as a fourth fundamental attribute to explain the mysteries of light, heat, and combustion. It is typical of the profundity of Aristotle that his fourth state of matter, designated "fire"—historically associated with transmutation, and definitely not to be restricted to chemical flame—retains a peculiar applicability for the field of nuclear physics. Perhaps we now would use the term "energy" to denote the concept.

In subclassifying the solid state, three kingdoms were recognized much as at present—

*The information and quotation is from "Wonders of the Past" (Vol. 2, p. 419), published in 1924 by G. P. Putman & Sons, New York City.

Page 195

1985

cury could be added as a seventh. Metals in ancient thought have always been seven in number, specific in esoteric significance, and closely related to such exoteric things as the planets and the days of the week:

Derivations for Sunday, Monday, and Saturday are obvious; but Tuesday similarly develops from the Anglo-Saxon *Tiw*, equivalent of Mars; Wednesday from the Saxon *Woden* and Scandinavian *Odin*, counterpart of the Roman Mercury; Thursday from the Scandinavian *Thor*, an equivalent of the Roman *Jove* (genitive term for *Jupiter*; witness the French *jeudi* for Thursday); finally Friday from the Norse *Frigg* who, as wife of Odin and goddess of the sky, corresponds to

Venus. These explanations help recover at least a fragment of an original logic in the above listings.

Thoughtless comment frequently deprecates these heritages because of an apparent nonconformity with our externalized science of today. However, those ancients who were first authorities in their field did not necessarily maintain that there were only seven elements to be classed as metals, nor only seven solar satellites. Their per-

spective was far removed from that of modern science, and often on levels of inquiry which at present are of only peripheral concern to science. Possibly some or even many of their discoveries may yet prove correct for the particular ontology they concern.

As for the semimetals, Gellert lists five: zinc, bismuth, antimony, arsenic, cobalt. His "antimony", however, refers to the sulphide ore,

Table II — A Decipher for Alchemical Symbolology

THE FOUR ELEMENTALS				
 FIRE (energy)	 AIR (gas)	 WATER (liquid)	 EARTH (solid)	
METALS ^b		SEMI - METALS ^c	MINERALS	
 GOLD	 ANTIMONY ^d	 VITRESCENT (hard refractories)	 GLASS	
 SILVER	 REGULUS OF ANTIMONY ^d	 FUSIBLE VITR. (flints, silicates)	 ANTIMONY GLASS (Sb oxide)	
 COPPER	 BISMUTH	 ARGILLACEOUS (clay, talc, mica) ^f	 LEAD GLASS (litharge)	
 IRON	 ZINC	 GYPSEOUS (plaster, gypsum)	33) CINNABAR (Hg sulfide)	
 LEAD	 ARSENIC	 CALCAREOUS (limestone)		
 TIN	 COBALT ^e	 CALX (slag)	 ORPIMENT (As sulfide)	
 MERCURY \Rightarrow	 Sublimed Hg  Precipitated Hg	 SAND		
ACIDS		BASES	SALTS	OTHERS
 ACID, in general	 FIXED ALKALINE SALT	 COMMON SALT (NaCl)	 SULPHUR	
 VEGETABLE ACIDS	 VOLATILE ALK- ALINE SALT	 SAL AMMONIAC ^h (NH ₄ Cl)	 HEPAR SULPHURIS (K sulphide)	
 DISTILLED VINEGAR	 ALKALINE SPIRIT (ammonia)	 SALTPETER (K, Na, Ca nitrates)	 SPIRIT (vapor, fume)	
 HCl	 QUICKLIME	 VITRIOL (metal sulphates)	 SPIRIT OF WINE (ethyl alcohol)	
 HNO ₃	 POTASH	 ALUM (double sulphates)	 RECTIFIED SPIRIT (>95% alcohol)	
 AQUA FORTIS (conc. HNO ₃)	 H ₂ SO ₄	 VERDIGRIS (Cu acetate, carb.)	 INFLAMMABLE SPIRIT	
 AQUA REGIA (HNO ₃ - HCl)	 OIL OF VITRIOL (66° B _x H ₂ SO ₄)	 BORAX (Na borate)	 INFLAMMABLE FETID OIL	
 POWDER	 URIN	 SOAP	 OIL	

whereas his "regulus of antimony" is the metal. The identification of cobalt is also open to question. Gellert's criterion is the beautiful blue color imparted to glass by "cobalt", and this seems secure, but other remarks indicate that a mineral is meant rather than cobalt metal. Here a passage from Gellert is interesting because nickel was discovered at about the time he was writing.*

Copper-nickel contains sometimes a good deal of copper, but this ore being commonly mixed with cobalt, the unmetallic earth of which renders its working very difficult and unprofitable, it is mostly placed among the arsenical ores. This is probably the ore of which Cronstedt makes a new semimetal, called nickel, which is nothing but a mixture of iron, arsenic, cobalt, and a little copper.

This use of "copper-nickel" is an ill-advised literal translation of the German "kupfernickel", used for the copper-colored mineral niccolite, an arsenide of nickel.

In closing these brief remarks on alchemical definitions of metals, semimetals, and minerals, the following two excerpts will not only lighten the burden of the review, but will call forth some useful reflections on the homely beginnings of our culture:

Goose silver ore (so-called from its exact likeness with the goose dung) is a marle-like, pale and brownish, very rich glebe, and often surrounded and interwoven with filaments of native silver. The same name is given to another sort of a greenish gray silver mineral, having

*Nickel was first isolated by Cronstedt in 1751 and obtained in a pure state by Bergmann in 1775.

nearly the same colour of that goose dung.

In collecting or purchasing of ores, care must be taken to prevent imposition: For, there are some ingenious fellows who know how both to compose artificial ores, and to join natural pieces so artfully together, that the cheat may not easily be discovered with the eye; and from whence many theoretical and practical errors may arise. Oftentimes this cheat may be detected by putting such mineral stones into hot water, or in brandy, for, if they are joined with gum or resinous substances, one or the other will make them fall in pieces.

Chemicals — By the term *dissolvent menstrua*, the alchemist referred to his solvents and corrosive agents. These were broadly divided between (a) "dry", exemplified by mercury, but including other substances leading to fusion by fire, and (b) "liquid", principally comprising aqueous solutions.

At certain stages of alchemical development, the term "salt" was used to signify the principle of solidity, in a triad of primary concepts including mercury for the principle of liquidity and sulphur for the principle of combustion. By Gellert's time "salts" were the acid, alkaline, or neutral residues of evaporated metalliferous acids (also called "vitriols", and sometimes "sugars"). Three naturally occurring vitriols were recognized: blue vitriol (copper), green vitriol (antimony), and white vitriol (zinc).

Considering the fact that analytical tools of precision are entirely a recent development, this pre-science did remarkably well in analyzing most of the simple inorganic salts. More complex

Footnotes to Table II on Opposite Page

(a) The principle of light, heat and combustion — or the essence of the Fire elemental — was termed "sulphur" by early alchemists, and "phlogiston" by J. J. Becher and his student G. E. Stahl in the late 17th century. Lavoisier's discoveries with oxygen broke that chain of thought and gave origin to thermodynamics, which in turn is perhaps now to give way to nuclear physics as the inheritor of the ancient metaphysical concept.

(b) Alchemical metals are characteristically these seven, though Gellert omits Hg. Their order of listing is constant for the Au-Ag-Cu triad, but variable for the others, although originally the geocentric Ptolemaic theory gave them order according to the supposed distance from the earth of the planet to which the metal referred.

(c) This listing of "semimetals", taken from Gellert, represents a late stage of alchemy. Although Sb may date back to very early times, Bi and Zn belong to the current millenium; and metallic Co was first isolated from the mineral and identified during the very period in which Gellert wrote. See also note (e).

(d) "Regulus of antimony" is the alchemical term for Sb, "antimony" referring instead to the sulphide ore *stibnite*.

(e) "Cobalt" undoubtedly refers to a metallic-looking mineral, probably the sulpharsenide *cobaltite*, analogous to the alchemical usage of "antimony" noted just above. The metal Co was isolated in 1742 by Brandt in Sweden and confirmed by Bergmann in 1790, this period also embracing the

publication date of Gellert's book.

(f) These particular examples taken from Gellert indicate the measure of the abyss existing between alchemical and technical petrography.

(g) "Alkaline salts" were variously prepared from minerals and vegetables to produce sodas and potashes. Gellert even gives a recipe based upon boiled bullock's blood which "foams much up" and emits a "foetid smoke". "Fixed alkaline salts" were accordingly the sodium and potassium carbonates and hydroxides, while the "volatile alkaline salts" were the ammonia compounds.

(h) This name descends from ancient Egyptian times when the salt was prepared from the soot of camels' dung burned in the great Temple of Jupiter Ammon.

chemicals received definitions which became more ambiguous and more metaphysical with increasing complexity of composition; witness the following: "Tarter is a neutral salt, consisting of the vegetable acid, an inflammable earth, and an ardent spirit".

Combustion—Just two centuries ago, C. E. Gellert published in Germany the book to which reference has already been made. An outstanding example of Teutonic thoroughness, the text was translated into English and presented to the Royal Society in 1766, finally being published as "Metallurgic Chymistry" in the year of our Declaration of Independence. Gellert was a student of the works of Henckel, Becher, and Stahl, these last two being the inventor and the outstanding exponent, respectively, of the phlogiston theory of combustion—probably the last great fragment of alchemy to be blasted away by the increasingly exact tools and methods of the new scientific era.

The phlogiston theory was an attempt to solve the great problem of heat and combustion. As Gellert defines it in Seifert's translation: "Every substance what is inflammable is in Chymistry called by the general name of *Sulphur*, or *Phlogiston*." Phlogiston was not regarded to be the thing itself, but rather a subtle substance or attribute which was able to pass in and out of the material.

Lavoisier laid the theory to permanent rest very shortly after Gellert's book was written, by his discoveries of the role of oxygen in combustion—a very special type of chemical reaction. Today, the advanced student of physical chemistry, in an attempt to discover why, and how far and at what speed a certain reaction may occur, marshalls thermodynamics, wave mechanics, statistical analysis, and the calculus of variations to his aid—possibly without getting much closer to the fundamental cause than did Becher and Stahl with their limited facilities.

The Alchemical Table

In the appended Table I there are 28 columns of alchemical symbols as given by Gellert. Table II provides a key to these symbols, also largely taken by the present author from the same source. Variations in the symbols are the result of the latitude of expression they allow. For example, headings for columns No. 4 and 5 in Table I show no crossbar within the triangle because they refer to *molten* gypseous and calcareous minerals, respectively, whereas the symbol in

the decipher (Table II) refers to the ordinary solid material.

At the top of each column in Table I is the signature or sign of that body or substance by which those beneath may be dissolved. Furthermore, the order from top to bottom is in the direction of increasing solubility "... because, by that means, in some columns, the order how they precipitate one another will then appear in the same time." For example, in the 14th column, sulphur dissolves "cobalt" (an arsenious sulphide) and arsenic with maximum difficulty, then mercury, antimony, bismuth, silver, lead, tin, copper in that order, with iron easiest of all. The second division at the bottom of the tabulation lists those materials which are completely insoluble within that particular column head (gold and zinc).

To aid interpretation of Table I, the column heads are decoded in Table III:

Table III—Code for Table I

COLUMN HEAD	SUBSTANCE
1	Hard refractories
2	Fusible refractories
3	Argillaceous earth or clay
4	Gypsum or plaster
5	Limestone
6	Fixed alkaline salt
7	Volatile alkaline salt
8	Distilled vinegar
9	HCl
10	HNO ₃
11	H ₂ SO ₄
12	Aqua Regia
13	Salt peter
14	Sulphur
15	Impure potassium sulphide
16	"Cobalt"
17	Arsenic
18	Antimony
19	Sb ₂ O ₃
20	Bismuth
21	Zinc
22	Lead
23	Tin
24	Iron
25	Copper
26	Silver
27	Mercury
28	"Glass"

Columns No. 1 to 15 and 28 are primarily of interest to the process metallurgist, and No. 20 to 27 to the physical metallurgist. Interest in chemistry and corrosion attaches to columns numbered from 6 to 19.

Corrosion—Beginning with the strong acids, *the spirit of common salt* +Θ (hydrochloric

acid) is stated to dissolve iron, copper, lead and tin—the latter “. . . with violence and great noise”. It slightly attacks mercury, but silver and gold not at all. When united with *spirit of nitre* $+ \oplus$ (HNO_3) “. . . in a due proportion it is called *aqua-regia* ∇R so named from being the only acid which dissolves the king of metals, gold.” *Aqua fortis* ∇ , as the aqueous solution of *spirit of nitre* $+ \oplus$, was stated to dissolve most metals and semi-metals, tin only slightly, and gold not at all—hence its use in “parting” gold from other metals.

As for *acid of vitriol* $+ \oplus$ (H_2SO_4), this was found to dissolve iron, zinc, copper, bismuth, arsenic, silver, and “cobalt”. It was found especially reactive with iron and zinc when diluted with 20 to 30 parts of water, thereupon emitting “. . . vapors of a garlic-like smell which are highly inflammable”. Only hot and concentrated solutions of acid of vitriol were found to attack copper and silver.

Among the weaker reagents, *oil* $\circ\circ$ and *spirit of wine* ∇ were found to attack copper and brass to some extent, which is an interesting observation with regard to our modern distilling industry. *Acid salts of vegetables* $+$, such as vinegar, were found to dissolve copper, lead and zinc, but not gold, silver or mercury. Copper was attacked by *oil of tartar per deliquium*; and the volatile alkaline salt $\oplus\Delta$ (ammonia) was found to dissolve copper, zinc, bismuth, sulphur, mercury, silver—also gold to a slight extent.

Alloying for Corrosion Resistance—In the following excerpt from Gellert, one sees the germinative stages of the present tremendous field of alloy metallurgy:

It is remarkable that not only these acid salts, but even metals will dissolve easier and sooner, when by themselves, than when united and mixed together. From hence depends the principle of etching with wood-vinegar, or with tartar and salt in the brass-works; and likewise the utility of brass pump-pipes in such mines where the waters are of a corrosive quality. For the same reason brass indures the air better than copper.

He goes on to list experiences with alloying which are of interest to a student of the history of this field. The adding of tin to copper to produce “hard metal for bells and guns . . .” was, of course, about as ancient for Gellert as it is for us, since this defined the Bronze Age; and the combining of zinc and copper to form brass stretches back toward the beginnings of the Roman Empire (although the use of metallic zinc for such purposes, instead of zinc ore, came far later).

Gellert's statement that lead dissolves in most metals except iron is pertinent to the modern use of leaded free-machining steels; and the discussion of embrittlement of metals by sulphur, arsenic and tin ties in directly with modern problems, still often costly, concerning hot short and cold short behavior during working.

Precursor of Galvanics and Thermodynamics—

In these several concluding excerpts, germinative stages of both electro-dynamics and thermodynamics appear:

. . . copper is obtained from those vitriolic waters by means of iron, which being put in and left there for some time, precipitates all the copper in its native form. For, the vitriolic acid having greater affinity with iron than with copper, instantly seizes upon that, dissolves it, and lets the copper fall down in its metallic form, which collecting in the same place, which the iron compasses, takes exactly the same figure as the piece of iron had when immersed. This phenomenon has caused the ignorant to believe, that iron has been transmuted into copper.

Expanding upon the features of galvanic plating, Gellert points out that silver

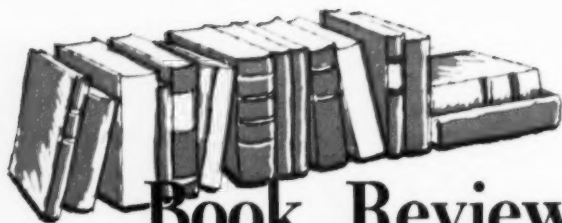
. . . will precipitate by throwing copper in the solution, copper with adding iron, iron with zinc, zinc with adding an alkaline-earth, and the alkaline-earth will precipitate with alkaline salt.

Today the Electromotive Table and measurements for $\Delta F = -nFE$ exactly define these phenomena formerly generalized by the alchemist. Relationships expressed today in terms of $\Delta F = -RT \cdot \ln K$ were also then in dim outline:

If therefore anyone of these mentioned bodies is united with sulphur, it may be divested of its sulphur by one of these bodies which stand under it in the same column [of the table].

Gellert pointed out that this does not always occur exactly as designated, for two reasons: (a) The difference between the two reactions is insignificant, and (b) the reactants may themselves dissolve one another. For example, he points out, iron and copper in column No. 24 dissolve with greater difficulty than Fe-Ag or Fe-Au; hence copper cannot be “parted” from iron by using gold or silver because these dissolve in iron themselves.

(Addendum by 20th century metallurgist: While Gellert's point is acceptable, his choice of an example is unfortunate. Silver has a scarcely measurable solubility even in liquid iron, whereas copper has an appreciable solubility in the liquid and gamma phases, and gold is completely miscible in the liquid, with a solubility near 10% in the gamma phase.)



Book Review...

Jet Engines

Reviewed by E. E. THUM

JET, THE STORY OF A PIONEER, by Sir Frank Whittle. 320 p. Frederick Muller, Ltd., London, 1953. 16s.

DEVELOPMENT OF AIRCRAFT ENGINES AND FUELS, by Robert Schlaifer (engines) and S. D. Heron (fuels). 750 p. Harvard University Business School, Boston 63, Mass., 1950. \$5.75.

THE FIRST of these books is almost exclusively devoted to Whittle's homeric struggle to develop jet propulsion for fighting aircraft, and is a human rather than an engineering document. Although he was the pioneering inventor, his was not the only intensive work on gas turbines in the 1940's, even in his own country, as might be surmised if only his own story is read. The book by Professor Schlaifer gives the international picture, and a far more complete one for the aeronautical, mechanical and metallurgical engineer.

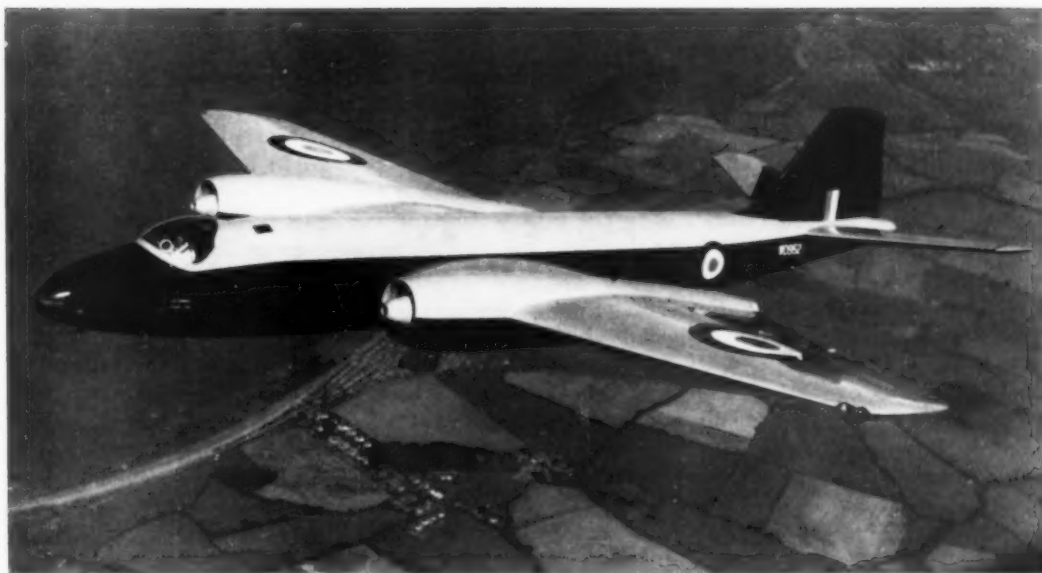
Whittle was born in 1907, the son of a hard-working "small business man" in the true sense of the term. When 10 years old he operated a lathe on spare time in his father's shop, making piston rings. A very poor student by school-teacher's criteria, he enlisted as aircraft apprentice when 16 years old and in three years became an expert rigger for metal aircraft—advanced designs for those days. This training served excellently in later years, for his early engines were largely sheet metal casings, ducts, vanes, burners, diffusers and tail pipe surrounding a forged shaft carrying turbine wheel and cast impeller.

As a flight cadet he wrote a paper on "Future Developments in Aircraft Design" wherein he was thinking of speeds of 500 miles per hr. at very high altitudes—truly advanced when it is remembered that the fastest British fighter could then make 150! Not until 1929 when training as a flying instructor, did he hit upon an engine for such a craft—a gas turbine thrusting the ship forward rather than a propeller pulling it.*

No encouragement was given the 22-year old flyer by the Air Ministry. Several former studies had concluded that the gas turbine would be impossibly heavy. Unfortunately, these estimates were made by men who based their figures on steam turbines and thought of the gas turbine as an engine to drive a propeller. Whittle's idea *was* revolutionary; it eliminated the propeller; he wanted to push the airplane through the air with a jet of hot air rather than pull it with propeller blades. Anyway, the common opinion was that there were no materials which would stand the high temperatures that were theoretically necessary.

As one of the bright young men in the R. A. F., however, Whittle was sent to Cambridge University to study mechanical engineering. During this time three of his former friends and instructors organized Power Jets, Ltd., to commercialize

*Propellers rapidly lose efficiency at 400 miles per hr. and in rarified atmosphere. The true jet gains efficiency in the colder air at high altitude. As shown in the comprehensive discussion of gas turbines published in *Metal Progress* in September 1944, shortly after the information was taken from the "secret" category, a gas turbine takes in air, compresses it, and burns fuel in this compressed air. The hot blast then impinges on turbine blades, giving up only enough of its energy to drive the compressor, the remainder going out the tail pipe in a jet of very hot gas. The reaction forms the thrust which drives the craft forward.



The Olympus-Canberra, Powered by Two Bristol Olympus Turbo-Jet Engines

his inventions. He was permitted to give the firm six hours a week and on graduation in 1936 was assigned to "special duty" to continue the engine work. Meanwhile his friends had raised some private capital and the first engine was put on test in April 1937, less than two years after work started. It had one combustion chamber and developed 480 lb. thrust instead of the 550 lb. calculated. A rebuilt, 10-burner engine was the next step; the Air Ministry started to make small contributions and contracted with Power Jets for a flight engine, and with Gloster Aircraft Co. for a ship to fly it in. The first flight was on May 15, 1941; P. E. G. Sayer was pilot; it lasted 17 min. and the ship made 370 miles per hr. in level flight at 25,000 ft., well above the best the "Spitfire" could do.

This induced the government to make plans for quantity production of such an outstanding performer and the job was given to the Rover Co. Ltd., makers of automobiles, with unfortunate results. Later, Rolls Royce's aircraft engine department was brought into the project and its Whittle-type "Weland" engine saw some service in Meteor aircraft after August 1944 against V-1 bombs. Its ratings compared with the German jet fighter's as follows:

	WELLAND (METEOR)	JUNKERS (MESSERSCHMITT)
Speed at sea level	410	520
Engine weight	850 lb.	1650 lb.
Thrust	1600 lb.	1980 lb.
Fuel consumption	1.12 per hr.	1.44 per hr.

Much of the book "Jet" is an account of troubles and misunderstandings with the Air Ministry and the commercial firms which were assigned the job of producing the engines. At any rate, Power Jets was kept in the status of a development organization and nationalized* at war's end. No doubt these disagreements, combined with excessive overwork, wrecked Whittle's nervous system and after periodic stretches of hospitalization he was retired from the Air Force in 1948, given an *ex gratia* award of £100,000 free of tax, and knighted. Possibly this was a fair reward for a man who — as he says in a footnote — "revolutionized aeronautics for the cost of two Comet jet airlines spread over eight years". He may have the added satisfaction of knowing that it is highly unlikely that at some future date a loyalty board will attempt to determine whether he can be trusted to advise his Queen's government about aircraft propulsion.

Whittle's book is designedly for the general reader, and makes small mention of the metallurgical problems encountered and studied by T. A. Taylor of his staff. The compressor rotor was cast by High Duty Alloys of aluminum alloy RR.56 (2 Cu, 1 Ni, 1 Mg, 0.9 Fe, 0.8 Si, 0.06 Ti). The first turbine wheel and blades were of Firth-Vickers "Stayblade" (20 Cr, 8 Ni, 1.2 Si, 1.3 Ti,

*That is, bought by the government — total private capital invested in Power Jets was £13,500 (pre-war; about \$130,000 in 1954 dollars). The British government bought all outstanding stock for £135,563 (1944 money; about \$400,000 in 1954 dollars).

0.22 C); the same firm's "Rex 78" of higher creep resistance (15 Ni, 14 Cr, 4 Mo, 4 Cu, 0.65 Ti, 0.3 V, 0.07 C) was used after 1939, and by the end of 1941 Mond Nickel Co.'s "Nimonic 80" (20 Cr, 76 Ni, 2.5 Ti, 0.6 Al) came into use for the hot areas. Turbine blades were cut to shape in machines designed by J. A. Kestell of United Shoe Machinery Co. Problems connected with the 20-fold rate of fuel consumption were solved with the help of a small Scottish firm, Laidlaw, Drew & Co., and I. Lubbock of Shell Petroleum Co.

The circumstance that so many firms participated in this development other than engine builders was repeated in Germany, as is clearly stated in Professor Schlaifer's "Development of Aircraft Engines". The pioneer there was a graduate student in aerodynamics, Hans von Ohain, who suggested in 1935 an engine like Frank Whittle's patent specification of 1930, of which he was completely unaware. The Heinkel aircraft factory was interested enough to build an experimental engine; in about a year a 550-lb. thrust engine was made at a cost of \$20,000. The world's first turbo-jet was a Heinkel and it flew Aug. 27, 1939, nearly two years before the Whittle-Gloster. Simultaneously, Herbert Wagner, of the Junkers Airplane Co., was building a jet engine of a different design; it was under test in mid-1938.


Space does not permit even an outline of the German wartime developments. Delay in getting the new fast aircraft into production was due to the Goering desire to make a large number of conventional aircraft for a short war. Messerschmitt jet fighters, each with two Junkers jet engines, did not come off the lines until early in 1944, but they immediately established superiority as a fast, short-range defender against anything the English or Americans could bring over Germany. About 1400 of them were built by the end of the war.

An extraordinary achievement in production and parsimonious metallurgy was these Junkers jet engines. The Air Ministry specified that no more than 500 man-hours be used per engine. Combustion chambers and other hot ducts were of aluminum-coated steel. The hollow turbine blades were made by welding two formed sheets of "Cromadur", a Krupp alloy containing 18% Mn, 12 Cr, 0.65 V, 0.5 Si, 0.2 N₂, 0.10 C, balance Fe. The turbine disk was a martensitic steel with no chromium or nickel. Turbine nozzles were hollow, and air cooled, of 12% chromium

steel. The complete engine used no nickel and less than 5 lb. of chromium. That's conservation of strategic alloys for you! The engine had a short life — perhaps 25 hr. — so had the fighter in which it was installed.

America was years behind these other countries. We had the plant resources and N. A. C. A. test equipment; better alloys in the "Stellites" and "Hastelloys". Austenal Laboratories had solved the manufacturing problem of turbine blades by investment casting. However, we had no Whittle or von Ohain. Likewise, our airmen were interested in low fuel consumption and long-range aircraft, and so spent their time in improving piston engines and developing turbo superchargers for high-altitude flying. These are in fact turbines driven by hot exhaust gases, in turn driving compressors, but they did not need to operate at high efficiency since there was a large surplus of heat in the exhaust. We did not get into the jet business until late in 1941 when the British sent over the first Whittle test engine (now in the Smithsonian) and a set of drawings to General Electric's Lynn plant. The first American-built engine of this sort was flown in a Bell airplane on Oct. 2, 1942, but the real American effort was toward engines of much larger thrust — 3000 and even 4000 lb. None of these were in use by the end of the war.

The Schlaifer and Heron book is subtitled "Two Studies of Relations Between Government and Industry". Professor Schlaifer assumes that a development as costly as a jet engine would not be undertaken by private industry without a government guarantee or subsidy. (As a matter of fact, Brown-Boveri in Switzerland went it alone in their gas turbines, and the patent situation and Whittle's connection with the R.A.F. were probably the largest deterrent to private financing in England.) Serious delays were occasioned by bureaucratic interference and departmental jealousies in all three countries, even in wartime. Finally, the real spark-plug, the fundamental idea, came from Whittle and von Ohain and not from a civil servant.

Such facts and numerous other generalizations in the Schlaifer-Heron book would make good reading for anyone interested in today's pressing problem of the rapid development of atomic power for public use — the question whether the lead is to be taken by a governmental commission, no matter of how high a quality, or by private competition in a capitalistic economy, source of most of our living amenities. 

Linings for Induction Furnaces

By H. E. WHITE*

Magnesia-alumina mixes and zircon are now favored for special steels and high alloys. The author presents many "do's" and don'ts for the melting superintendent, and backs up his advice with facts about properties of the minerals and the refractory manufacturing processes.

IN HIS FAMOUS monograph on "Principles of Inductive Heating With High-Frequency Currents", written in 1919, Prof. E. F. Northrup named silica sand, lime, magnesia, alumina, and zirconia as possible refractories for use in his furnace. He further stated, "When fine sand is used as a refractory, a thin wall of silica fuses about the molten steel and entirely prevents any flow or leak from the molten mass."

It would be nice if we could stop right here. It would appear there was no refractories problem 25 years ago. It is different now. Dr. Northrup could not have glimpsed the potentialities of his invention.

In most of the small, early furnaces, the metal was usually contained in graphite crucibles or the old "sand crucible"—that is, a clay crucible having siliceous material as the grog. Today, non-ferrous (and some ferrous) metals are still melted in clay-graphite crucibles of special composition and the crucible itself is semi-conducting. Small melts of ferrous metals and alloys are usually melted in magnesia crucibles; alumina and zircon crucibles are sometimes used. Zircon is particularly useful where an acid refractory is desired. Beryllia and thoria serve in researches where contamination of metal must be kept to a minimum.

Except for the rare oxide refractories, the crucibles present few problems since their manufacture is now well standardized and they are

easily and quickly replaced when they wear out.

Our present discussion concerns furnaces which are too large for the economical use of crucibles and which melt alloy steels and heat or corrosion resistant alloys.

In order to evaluate the available materials, it is necessary for the refractory manufacturer to know a good deal about the crystalline minerals now available, some in nature, most of them synthetic. This is especially true when the user makes a lining for himself rather than builds one up from the fired refractory shapes. We must separate the physical characteristics of the minerals themselves from the mass of data on fired shapes, since we are dealing with the aggregate itself. This requires some technical details but it is our premise that the more known about any material, the more efficiently it can be used. If longer life is to be obtained from linings, then their limitations must be known—their good as well as their bad points.

From our present knowledge of refractory materials, as well as their cost and availability, we are commercially limited to granular aggregates of crystalline alumina ("corundum"), crystalline magnesia (of the mineral periclase), silica (which has many names depending on its crys-

*Vice-President, Director of Research, Lava Crucible-Refractories Co., Zelienople, Pa. Portions of a paper presented before the Pittsburgh meeting of the Electric Metal Makers' Guild, Oct. 17, 1953.

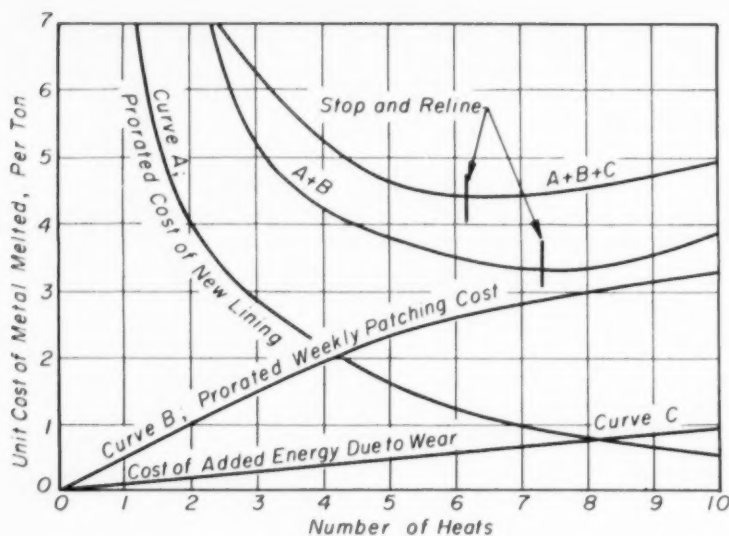


Fig. 1 — Curves Showing Economical Limits of Lining Maintenance

stalline state) and zircon (the silicate). Zirconia (the oxide), beryllia and thoria are so far luxury items. Chrome ore or chromite is an unsatisfactory material because chrome refractory continues to shrink with use, and also has other disadvantages.

Hints on Furnace Linings

In the supplement we will give some of the physical data which confirm our belief that, for induction furnaces melting steels, high-tempera-

ture alloys, and corrosion resistant materials, the satisfactory commercial linings are now appropriate mixtures of magnesia and alumina or are of zircon. This is shown in Table I.

Now for the lining of the furnace in detail. Many operators have their own ideas and their individual practices undoubtedly work well for them. However, the following are some thoughts distilled from experience with many installations over a quarter of a century worked out in conjunction with the Ajax Electrothermic Corp.

First, let us take the coil itself: The refractory on the coil must (a) adhere to the copper coil; (b) it must not contain electrically conductive materials nor water-absorbing materials such as sodium silicate, chlorides or phosphates; (c) it must air-set and stay hard, and (d) it must resist metal break-throughs.

The best practice is to coat the coils with an adhesive alumina cement—one that does not carbonize on heating—then ram the spaces between the coils with a nonshrinking, grog-type, mullite plastic, and coat the entire inside cylin-

Table I — Relative Service Figures of Linings

TYPE OF ALLOY MELTED	TYPE OF LINING	SIZE OF UNIT, LB.	LIFE IN HEATS	TYPE OF OPERATION	POURING TEMPERATURE	REMARKS
Stabilized stainless steel	Magnesia-alumina, 60-40	2,000	60 to 170	Intermittent	3,000 plus	Some patching done
Stainless steel	Magnesia-alumina, 60-40	4,000	More than 100	Intermittent	2,950	Little patching
Ni-Cr and Mo-V-Mn steel	Magnesia-alumina, 60-40	1,000	30 to 40	Intermittent	3,000 plus	No patching
Stainless steel Ti-Co-W	Magnesia-alumina, 60-40	4,000	70	Intermittent	3,000 plus	Some patching
Heat resisting Ni-Cr-Fe with Ti, Co, W	Magnesia-alumina, 70-30	4,000	80 to 90	Intermittent	2,950	Some patching
Heat resisting alloys	Magnesia-alumina, 70-30	1,000	15 to 20	Intermittent	3,000 plus	Some patching
Low-carbon steel	Zircon	3,000	30 to 50	Continuous	2,950	No patching
Stainless steel	Zircon	2,000	60	Continuous	3,100	Some patching
Jet engine parts	Zircon	1,000	90 to 150	Intermittent	3,050	Considerable daily patching

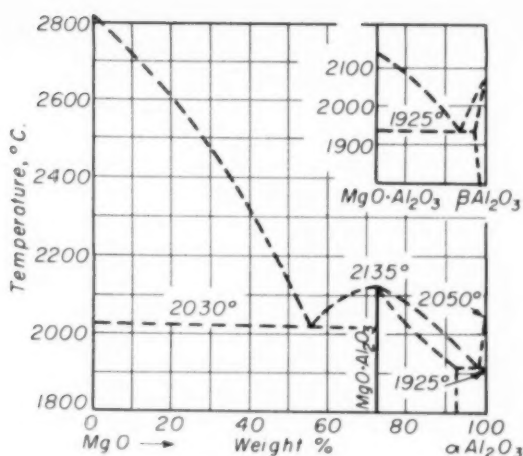


Fig. 2 — The $\text{MgO-Al}_2\text{O}_3$ Binary System

der and outside with adhesive cement. In this way the whole coil is kept rigid and is protected; furthermore, fine steel or iron particles are kept away from the surface of the copper coil.

CAUTION — Be sure the coil supports are in good shape and not charred.

The Lining Itself — First, secure a good form. (In small furnaces the crucible acts as the form.) A good radius at the bottom edge is quite necessary but the bottom should be flat so that the refractory can be well compacted in this region. Depending on size of the furnace, the radius blending the bottom to the side should be proportioned so the rammer can properly knit the bottom zone to the side walls.

If you melt out the form, make it of steel sheet or thin plate and only tack weld it together for some flexibility — a completely welded, stiff form might disrupt the lining by its expansion when heating it the first time. Transite or asbestos forms are also used with good results but are more expensive than steel.

The dimensions should be the proper ones specified by the furnace manufacturer. Any deviation either way is uneconomical. Too thick a lining reduces the furnace efficiency, let alone the capacity; too thin a lining imperils the coil. A tapered liner is better than a straight cylinder since it is easier to remove and gives a somewhat thicker lining in the bottom area.

The ramming tool should have a face $3 \times 1\frac{1}{4}$ in. or smaller. A chipping air hammer with a short stroke should be used; air pressure should be 80 to 100 lb.

During lining the water in the coil should be at about 100° F. to prevent any water from con-

densing in the refractory adjacent to the coil. Thermostatic valves controlling the coil line are advisable.

As mentioned above, the most popular and most generally serviceable lining is the magnesia-alumina type. Zircon linings, used early in this work by Dr. Northrup but now improved in both bond and aggregate, are finding their place in many applications. These two types constitute almost all the induction furnace linings in this country.

Such linings are handled somewhat like plastic materials. Most of the magnesia-alumina mixtures are rammed dry in layers about 2 in. thick. However, dry ramming is not absolutely essential; up to 2% water may be added and a removable form used if care is taken in the drying. Zircon is usually rammed in a slightly damp state and the form removed.

First, ram in the bottom well and roughen up the edges, then place, center and weight the form down heavily. It is important to hold the form in correct position.

Then proceed with the lining operation, layer by layer. Density is very important but don't over-ram, as particle segregation may result. It is important to remix any lining material before using. Some weird examples of segregation have been observed during short truck hauls to trans-continental shipments.

When the lining is completed, it is usual to seal the top with a good air-setting cement such as used on the coil. This helps hold the lining in place and counteracts the upward pressure from molten metal. It also resists mechanical abrasion during charging.

On the first heat as well as on subsequent heats put the heavy parts of the charge in the bottom and feed the light scrap later. This early precaution vitrifies the lining by getting the power in the proper place at the right time and gets the lining off to a good start.

Maintenance and Repairs

There is no problem in maintaining graphite crucibles. With some extremely high temperatures, small surface hair cracks or checks may develop, but a wash of high alumina cement will not only seal these over but keep the crucible clean in subsequent melt by causing any slag to part from the surface.

Due to its various changes of crystal state, silica (ganister) is a good packing material between the coil and the graphite crucible. It does not sinter readily at operating temperatures.

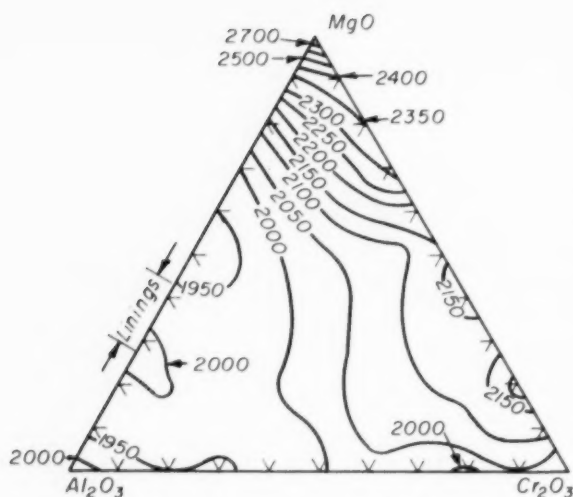


Fig. 3 - Melting Points of the $MgO-Al_2O_3-Cr_2O_3$ System. Isothermals noted with $^{\circ}C$.

The same remarks about maintenance are true of crucibles other than graphite. Cements of alumina, zircon, and magnesia are available for sealing minor cracks and filling in washed-out places. Backing material should be similar in composition to the crucible.

Linings—In the larger furnaces it is very difficult to maintain linings under 24-hr. operation and it has become quite common to double the number of units so furnaces can be alternated day to day, repairing the ones which are down.

With magnesia-alumina mixes one can make some emergency hot patches in sidewalls by putting in a partial charge to blanket the heat and then bracing a piece of sheet iron against the spot requiring patching, and tamping some of the original lining material into the cavity back of this. Use a solution of boric acid to bond the lining material or a prepared patching material of the same type as the original lining.

Excess slag may be removed on down furnaces that are relatively cool. Do not break all of it away down to the original mix—just the warts and adhesions. (This is true for zircon as well as magnesia-alumina linings.) Wash the lining with a prepared fine-grained slurry containing an adhesive bond, and then patch deep depression with a coarse mix, hand-troweling the material into place. Finally, wash with the fine-grained mix. (Some melters do not use it, but since the demand for the fine mix is increasing, it must work and it does help.)

Patched linings must be dried overnight with

electric strip heaters or a low gas fire.

For patching, up to 25% of old material in good condition from the backing of worn-out linings can be utilized provided no metal or slag particles are included. One-half to two percent (0.5 to 2.0%) of a saturated solution of boric acid or 1% of silicate of soda may be added for bond. A saturated solution of boric acid (commercial grade) is about 25 parts by weight to 100 parts of water.

There is a tendency to overdo the patching idea. In some instances more patch is used than the quantity of original lining material remaining in the furnace. Figure 1 is a set of curves made by the author some years ago showing the fallacy of this.

Do's and Don'ts for Induction Furnaces

Don't leave metal heels in the furnace.

Remove slag as made.

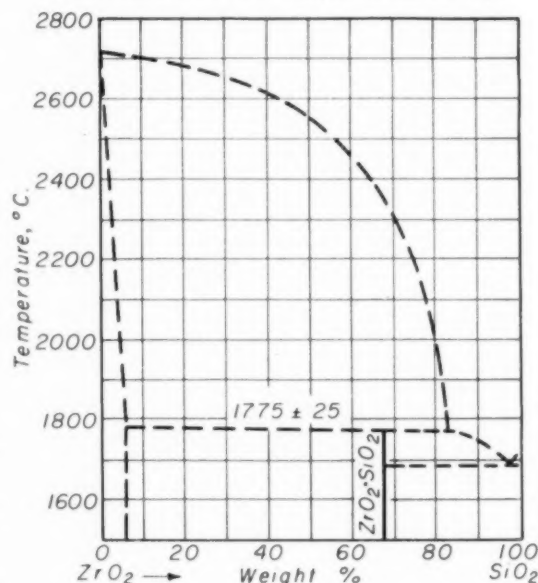
Keep down bridging.

If the bottom comes up, shut the furnace down; it is almost impossible to patch a poorly installed bottom.

Run melts at different levels to distribute slag action and minimize its effect.

Slag Attack—With these very thin linings, the slags must be kept at a minimum. Magnesia is,

Fig. 4 - The ZrO_2-SiO_2 Binary System According to Geller and Yavorsky, National Bureau of Standards, Research Paper 1662 (1945)



of course, basic and zircon is acid. The magnesia-alumina mixture is a very close to neutral in its reaction.

Further than this, the method of installing and the efficiency of the operation of individual installations has a greater effect on slag resistance than most other factors. This is particularly true about the top area.

Equilibrium Diagrams

Now let us take a quick look at some of the scientific facts underlying the best refractories for induction melting of iron alloys. We can start with the pertinent equilibrium diagrams, remembering that they apply to highly purified components rather than more impure natural minerals. Oddly enough, the two types of lining materials that are most used are, or eventually become, binary compositions—namely, magnesia-alumina (forming on use a synthetic spinel) and zircon, a natural binary mineral.

Figure 2 shows the magnesia-alumina binary diagram. The mixes recommended in Table 1 (60-40 and 70-30 $\text{MgO-Al}_2\text{O}_3$) are to the left of the $\text{MgO} \cdot \text{Al}_2\text{O}_3$ compound, and if the minerals were pure, melting would not commence until the mix reached 2030° C. (3690° F.)—ample for our uses.

The magnesia-silica binary system shows a low point at 1543° C. (2800° F.) for mixes containing more than 60% SiO_2 , indicating the advisability of keeping away from this range of composition. We stress this point because there are some lining materials made from converted olivine, a natural magnesium silicate plentiful in the southern states and relatively low in refractory value. At high temperatures olivine becomes mainly the mineral forsterite—existing also in electrically fused magnesia in small quantities. Silica in the latter must be kept below 3%, else the forsterite which forms acts as a lower-melting lubricant between the periclase grains.

Figure 3 shows the reason why there is a heavy slag build-up on magnesia-alumina linings when melting heats containing chromium. Any chromium oxides may combine with the magnesia and alumina forming a refractory slag; isothermals show that Cr_2O_3 does not lower the melting point of the $\text{MgO} \cdot \text{Al}_2\text{O}_3$ combination. Iron oxide is also absorbed by the magnesia in appreciable amounts without lowering its melting point. Application of a zircon wash in the upper area of the lining will facilitate removal of the slag ring.

The binary $\text{ZrO}_2\text{-SiO}_2$ diagram (Fig. 4) shows



Fig. 5—Pouring Alloy Steel Castings From Induction Furnace. (Battelle Memorial Institute)

a rather low-melting eutectic with over 95% SiO_2 , but this is of little interest to zircon refractories. They conform to the compound $\text{ZrO}_2 \cdot \text{SiO}_2$, which has a change point and incipient melt at 1775° C. \pm 25 (3250° F.). What little work has been done on the ternary diagrams indicates some lower-melting eutectics with alumina.

Physical Properties of Commercial Refractories

The equilibrium diagrams do not, of course, tell the whole story. There are some unusual mineralogical characteristics encountered in the materials now in use. We must rely on the evident compounds formed rather than on the melting points of the individual oxides.

Thermal Conductivity—Magnesia, in its crystal form, has higher thermal conductivity than zircon. As shown in Fig. 6, the order of increasing conductivity is zircon, silica, alumina, and magnesia. However, this order is not followed, necessarily, in the crushed and prepared aggregate, since the packing of the material is an important factor.

For example, some very excellent work was done at Massachusetts Institute of Technology and published in the *Journal* of the American Ceramic Society in 1954 concerning fine-grained crystalline materials formed into shapes and fired. The data were then calculated to zero porosity and show that silica has somewhat lower conductivity than zircon. For example, at 1200° C. (2200° F.) silica has a conductivity of 0.008 cgs. units whereas zircon has 0.0098.

Electrical Resistivity—Figure 7 shows the increasing order of resistivity to be zirconia, silica,

zircon, alumina, and magnesia—the magnesia having by far the greatest resistivity. Alumina and magnesia have very low electrical conductivity at temperatures less than 2000° C.

The low electrical resistivity of zircon may be indicated in the electrical circuit of the induction furnace, when compared to one lined with magnesia of high resistivity.

Zirconia becomes a conductor at 1500° C. (2730° F.) and is therefore used for heating elements at high temperatures as well as susceptors in ultra-high-frequency induction furnaces.

Electrical resistance of oxides usually decreases with increasing temperature; with metals, the reverse is true.

Thermal Expansion—Silica is notoriously fickle; it has at least eight crystalline modifications, most of them with high expansions. There is also a very large expansion when alpha cristobalite transforms to beta. Quartz glass, on the other hand, has a much lower thermal expansion.

In general, it may be said that graphite has the lowest thermal expansion of all commercial refractories, about one third that of zircon, alumina and stabilized zirconia. Magnesia has the highest expansion.

Recent results are summarized in Fig. 8.

Notes on Commercial Refractories

Silica is very seldom used to line coreless induction furnaces in this country, but is used to a certain extent abroad.

Magnesia-Alumina—Both natural magnesia

Fig. 6—Thermal Conductivity of Crystalline Refractories. Dashed lines from Journal of the American Ceramic Society for 1954, part II; full lines from same journal for 1938 except those marked (X), which are from American Institute of Mining and Metallurgical Engineers' Technical Publication No. 817

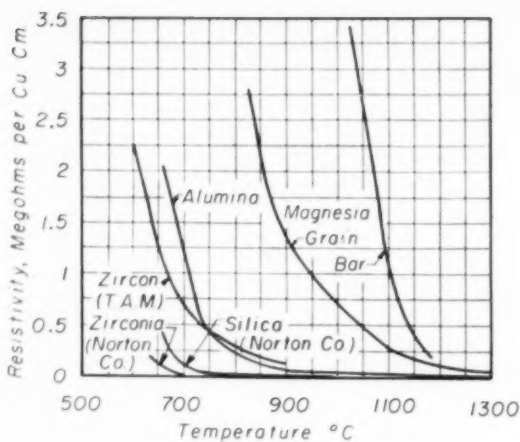
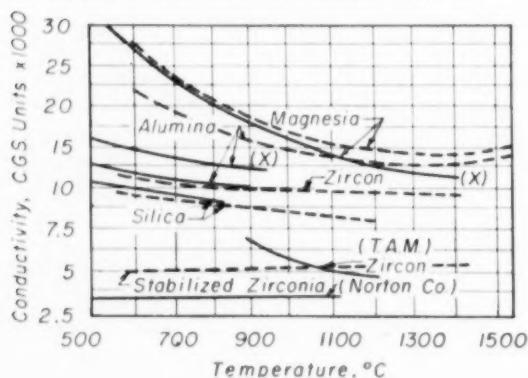


Fig. 7—Curves of Electrical Resistivity of Crystalline Refractories (Journal of the American Ceramic Society, 1938)

and alumina shrink continuously at high temperatures unless they have been previously completely converted to the crystalline state by fusion. Crystalline magnesia has, moreover, the property of absorbing several times its own weight of iron oxide without seriously impairing its use as a refractory. This distinctive property is possessed by no other known refractory.

Many years ago it was found that crystalline magnesia and crystalline alumina work best in combination, forming—as time at temperature progresses—a very refractory spinel. J. H. Chesters, discussing induction furnace linings in his well-known book on "Steel Plant Refractories" gives some data on the firing expansion of these mixtures, and finds that the 30-70 ratio (approximately pure spinel, $MgO \cdot Al_2O_3$) has the highest firing expansion of 9.4%. On the other hand mixtures with less than 40% Al_2O_3 are quite stable in size under continuous heating. (Fig. 9).

He further states that the expansion is due to the fact that the specific gravity of the spinel is considerably less than the average specific gravity of the constituents, and the reacting grains are forced apart when spinel forms at the interface. One practical result is that this reaction causing permanent expansion takes place to a large extent on the inner face of the lining where it is hottest and actually tends to hold the lining rigid—at the same time increasing the resistance to the slag.

Zircon—Chesters has this to say in his chapter on induction furnaces (p. 376 of the 1946 edition): "Zircon shows marked possibilities since it

does not shrink when fired, is highly refractory and resistant to slags high in iron oxide. The difficulty in its use lies in finding a suitable bond, such materials as fireclay being readily attacked and the undissolved zircon grains float out into the melt."

That was written in 1946, and is contrary to the trade literature on American refractories, which states that the presence of iron oxide in the melt reduces the life of the lining considerably. While the melting point of zircon is high, it begins to dissociate into zirconia (ZrO_2) and silica glass at about 2800° F. When heated for an extended period about 3100° F., the dissociation is practically complete; higher temperatures volatilize the silica and at the end we have a fused zirconia. Zircon is not recommended, therefore, for use above 3200° F. (1760° C.); however, it

charge, do attack. Medium-carbon and high-carbon steels do not usually give this difficulty. Zircon is an acid refractory and it should not be used in contact with basic slags.

The mineral zircon is the silicate and should not be confused with zirconia, the stabilized oxide. Zirconia of 98 to 99% purity has a melting point of approximately 5000° F. (2765° C.). Changes in crystal form take place at about 2100° F. (1150° C.) into the high-temperature monoclinic form. Monoclinic zirconia is reconverted into the stable cubic crystal by reacting it with a small percentage of certain oxides, the common one being lime. There is little or no reduction in melting point. Zirconia in its stabilized form is quite expensive and its relatively high electrical conductivity may cause trouble in linings for induction furnaces.

Beryllia, at present not plentiful, has low electrical conductivity but high thermal conductivity, the reverse of zirconia. Perhaps some day a useful combination of these might be worked out.

Chrome refractories unfortunately shrink and vitrify continuously at high temperature. Under some conditions they also disintegrate. Combinations of chromite with another oxide, similar to the combinations of alumina and magnesia, have not been successful as induction furnace linings, even though combinations with other minerals have made good refractory brick as well as fused-cast refractories.

Aggregate Shape and Packing—The average grain size and shape and grain size distribution have a great deal to do with the density of the furnace lining. Crystalline magnesia is the prod-

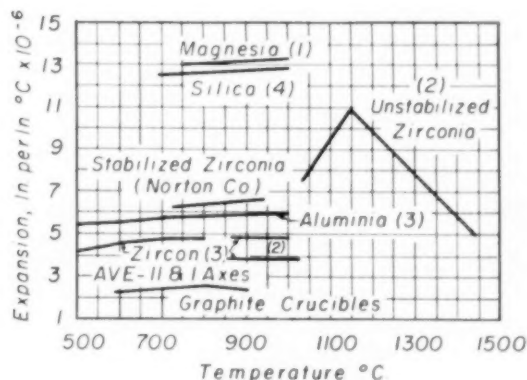


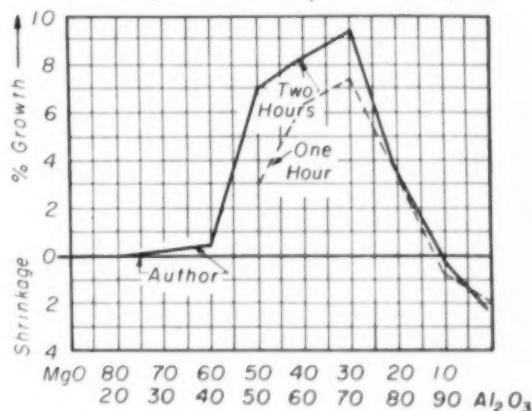
Fig. 8—Variation of Linear Thermal Expansion With Temperature. References: 1 and 3—Journal American Ceramic Society, 1938 and 1931 respectively; 2—Titanium Alloy Manufacturing Division's Booklet; 4—Harbison-Walker Refractories Co.'s "Modern Refractory Practice"

has been used successfully in short runs at much higher temperatures.

A leading manufacturer's booklet states that under reducing conditions up to 2900 or 3000° F., it is possible to dissociate zirconium silicate (zircon) and transfer silicon and zirconium to the melt. The present author has not substantiated this statement.

Zircon also reacts at high temperature with the oxides of iron or copper—the lower oxides more readily than the higher. In general, zircon is not appreciably affected by ferrous metals themselves. However, the oxides of iron that may be present in low-carbon steel or in the

Fig. 9—Permanent Growth of $MgO-Al_2O_3$ Mixtures after Heating to 1600° C. (2910° F.) for 1 or 2 Hr. (Chesters, "Steel Plant Refractories", and present author)



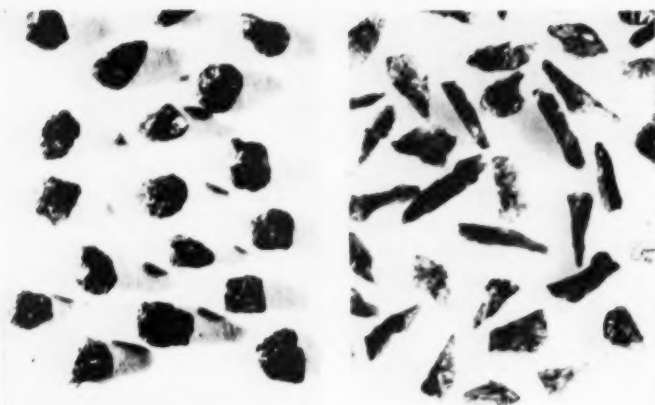


Fig. 10 - Fused Alumina Particles From Two Types of Crushers. Natural size

uct of fusion, so it is possible to have any grain size. Moreover, the crystal itself is blocky and solid, so the material is crushed and carefully sized. This operation is most important; slight changes in the equipment and routine make large changes in the product. For example, Fig. 10 shows magnified views of fused alumina grain from two different types of crushing. Obviously particle packing and particle shape have a great influence on any compact.

On the other hand, the mineral zircon is a fine sand (Fig. 11) typically 89% through 100-mesh screen. To secure the coarse aggregate necessary for furnace use, the sand must be synthetically bonded, fired, crushed, and screen-sized.

If all particles could be crushed in cubical shape and packed cubically, the porosity of the resultant body would be zero, provided that air absorption were negligible. (Carbon black may have as high as 95% air in the voids about the particles; incidentally, it is a good heat insulator for this reason.)

If spheres are packed so their centers are arranged on a cubic lattice, the percentage of voids is the same whether there is one sphere or a number of spheres of equal size, provided their diameters are exact multiples and each sphere is directly on top of the one below it. The voids are then 47.6% of the whole. By different arrangement of the spheres, as in a hexagonal lattice, this can be reduced theoretically to 26%. By fitting in smaller spheres up to five stages, the actual theoretical porosity can be reduced to 3.9%; even then, the primary spheres still constitute 77% of the mass.

It is, of course, impossible commercially to attain either these shapes, sizes, or packing.

Actually, porosities as low as 10% have been attained on a laboratory basis, but figures of 15 to 20% are normal. Magnesite-alumina linings usually measure 18 to 25% in porosity, and zircon linings 20 to 25%.

Since the shape of the particles plays an important part, well-rounded sand grains have 2 to 5% less voids than corresponding sharp grains.

The effect of moisture is also unexpected. Moist sand occupies more space per unit weight than dry sand packed in the same manner, since the film of water coating each grain is thicker than

the corresponding film of air.

The pore space in an aggregate, then, depends on the ratio between the size of the particles, their shape, and their packing arrangements. Surface areas and the porosity of the grains themselves must be considered. Some commercial refractories which have relatively low porosity seem to have been made by men who knew a good deal about the laws of particle packing, both in the manner of packing of the grog grains and in the shape of the grains themselves. At any rate, it is always well to remember that in any mixture of grains it is always difficult to get the highest density without some segregation of mineral or of shapes. Here again is the warning that all materials should be carefully and thoroughly mixed just before being placed.

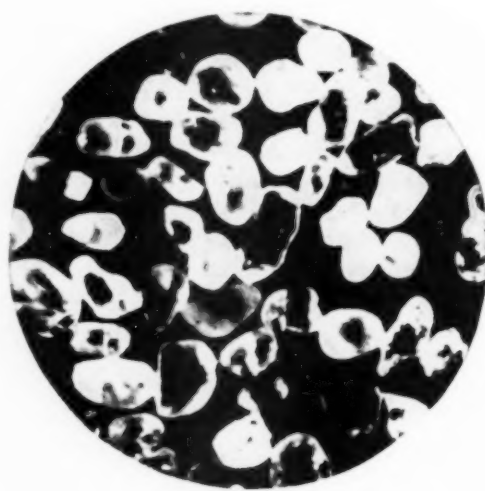
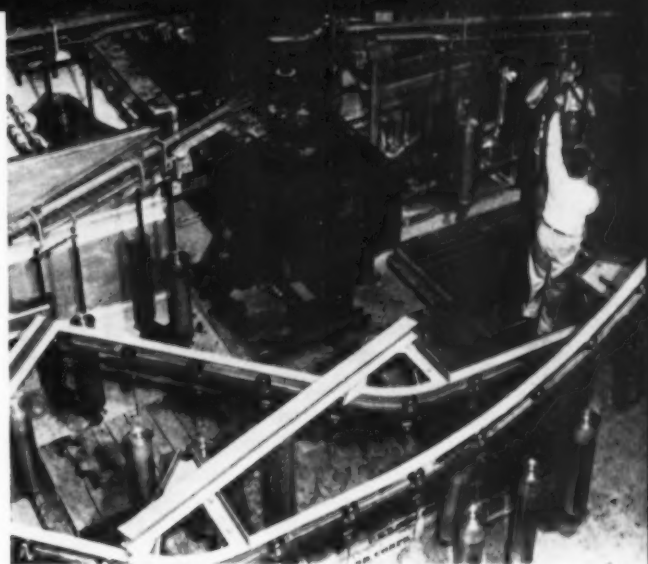


Fig. 11 - Grains of Zircon Sand, 50 X

Fig. 1 — Loading and Unloading Station of Hanson-Van Winkle-Munning Automatic Plating Machine at Riverbank Ordnance

Procedures and equipment used at Riverbank Ordnance to plate cartridge cases.



Automatic Zinc Plating

*By C. E. FISHER and D. F. ZLATNIK**

WHEN the use of steel in place of brass for cartridge cases was proposed so as to conserve the wartime supplies of copper and zinc, one of the limitations of this substitute which had to be overcome was its low resistance to corrosion, especially in marine atmospheres. According to Specification O.S. 1394, "Specifications for the Corrosion Resistance Requirements of Steel Cartridge Cases", published by the U.S. Naval Gun Factory, these requirements are as follows:

1. No process shall be approved by the Bureau of Ordnance which involves a coating which will react with or in any way affect the propellant or any other ammunition component with which it may be in contact in service.

2. No process shall be approved which requires an application of material greater than 0.0005 or less than 0.0002 in.

3. All cartridge cases shall withstand a 20% salt spray at room temperature for 120 hr. without exhibiting rust from the base metal, and shall not show any accumulation of corrosion products (from the decomposition of the coating itself) sufficient to prevent their gaging. The coatings used shall withstand the corrosion ordinarily produced by contact of dissimilar metals at the mouth and primer chamber. The coating shall also prevent any formation of rust when the cases are scratched through to the steel.

4. All coatings shall withstand deformation without any loss of adherence, flaking or peeling.

5. All coatings shall be free from imperfections such as uncoated areas, scratches, abrasions, checking or peeling.

The contractor is permitted some latitude in the establishment of a process for applying the protective coating on steel cartridge cases, but it must first receive the approval of the Bureau of Ordnance. The process selected for use at the Riverbank Ordnance Plant (operated by Norris-Thermador Corp.) has three functions: (a) preparation of the surfaces for zinc plating, (b) application of the zinc plate by electrodeposition in an alkaline cyanide plating bath, and (c) application by electrolytic action of a zinc chromate conversion film to the zinc plate. Twenty-three operations listed in Table I are needed to accomplish these basic functions on the 5-in. 38-caliber cartridge cases shown in Fig. 1. (The operation shown in the illustration is the loading of the cases for processing in the automatic plating machine manufactured by Hanson-Van Winkle-Munning Co., Matawan, N.J.) Figure 2 shows the arrangement of the processing stations around the central conveyer structure.

*Mr. Fisher is quality control manager, and Mr. Zlatnik is chief process engineer, Riverbank Ordnance Plant, Riverbank, Calif.

Preparation of Work for Zinc Plating

Cathodic Electrocleaner—This operation removes grease, oil and other soil to assure uniform acid pickling in a subsequent operation. A solution of 8 oz. per gal. of a proprietary alkaline cleaner compound operated at a temperature of 140° F. is employed. A current density of 30 amp. per sq.ft. produces the desired cleaning action. Although the work can be made anodic in this operation, best results are obtained with the work cathodic.

Overflow Rinses—Fresh water is continuously pumped into each of the two overflow rinse tanks that follow the electrocleaner to reduce contamination with rinsed-off chemicals to a minimum. Top sprays are used for additional rinsing action in the second tank.

Pickle—The film of iron oxide at the mouth of the cartridge cases is removed by pickling in a 10% solution of sulphuric acid at 150° F. A pickling inhibitor is added as required to prevent excessive attack on the steel underneath the oxide.

A second pickling operation (similar to the preceding) removes acid-soluble soil and superficial oxides from all surfaces of the work. A wet-

ting agent as well as an inhibitor is used in this pickling solution. The wetting agent increases the effectiveness of the inhibitor. A cold rinse and spray follow.

Anodic Electrocleaner—The second electrolytic cleaning removes pickling smut, acid insoluble soil, and iron salts which may be formed from the pickling action. A somewhat stronger (12 oz. per gal.) solution of the same proprietary alkaline solvent as used in cathodic cleaning is employed in this one and at the same temperature (140° F.). The work in this operation, however, is made anodic to prevent the electrodeposition of any metallic impurities present in the solution. The remaining steps in the cleaning cycle are a fresh water rinse, acid rinse and then two more rinses in running water. The acid rinse is a 10% solution of sulphuric acid without inhibitor, operated at room temperature. Its purpose is to remove any oxide films caused by the action of the electrocleaner.

Zinc Plating

There are four factors over which close control must be exercised to assure the continuous production of a satisfactory zinc coating: (a) current density of the internal and external plating

circuits, (b) composition of the plating solution, (c) temperature of the plating solution, and (d) maintenance of the workholders.

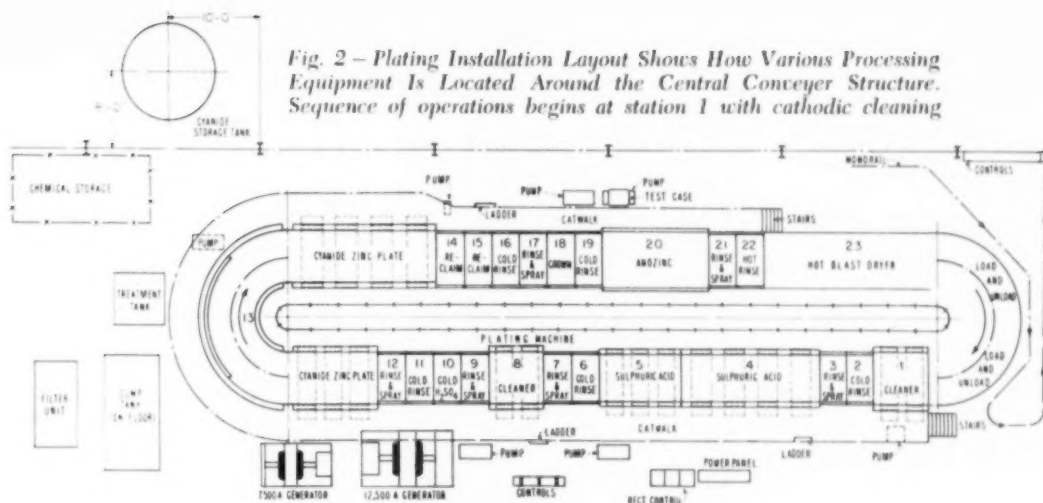
The first of these is controlled by adjustment of the voltage controls of the direct-current generators to obtain the prescribed current density on each circuit. Representative samples are examined daily to determine that the plating thickness meets the requirements of the specification. A coating 0.0003 to 0.0004 in. thick is deposited with a current density of 35.0 to 37.5 amp. per sq.ft. of surface to be plated.

The plating bath is a conventional cyanide zinc solution maintained at the following nominal concentrations: sodium hydroxide, 15 oz. per gal.; sodium

Table I—Operations in Automatic Zinc Plating at Riverbank Ordnance Plant

SEQUENCE OF OPERATION	PROCESSING SOLUTION	CONCENTRATION	TIME, SEC.	TEMPERATURE	CURRENT DENSITY*
Cathodic clean	Turco Prosolv B	8†	56	140° F.	30
Overflow rinse	Water		11		
Overflow rinse	Water		11		
Mouth pickle	Inhibited H ₂ SO ₄	10%	191	150	
Over-all pickle	Inhibited H ₂ SO ₄	10%	101	150	
Over-all rinse	Water		11		
Over-all rinse	Water		56		
Anodic clean	Turco Prosolv B	12†	56	140	30
Overflow rinse	Water		11		
Acid rinse	Inhibited H ₂ SO ₄	10%	11		
Overflow rinse	Water		11		
Overflow rinse	Water		11		
Zinc plate	NaCN	‡	416	90	35
Reclaim	None		11		
Reclaim rinse	Water		11		
Overflow rinse	Water		11		
Overflow rinse	Water		11		
Overflow rinse	Water		11		
Anozinc	Anozinc	32†	186		10
Overflow rinse	Water		11		
Overflow rinse	Water		11	125	
Dry	None		236	150	

*Amp. per sq. ft. †Oz. per gal. ‡Sodium hydroxide 15 oz. per gal.; sodium cyanide 15 oz. per gal.; zinc 5.5 oz. per gal.; sodium cyanide to zinc ratio 2.75.



cyanide (total), 15 oz. per gal.; and zinc metal, 5.5 oz. per gal.

Although the large volume of the plating bath (10,700 gal.) prevents rapid changes in composition, a chemical analysis is made during each 8 hr. of its operation. Additions of caustic, cyanide and zinc anodes are made daily to replace the losses from drag-out of solution and electrodeposition of zinc. The ratio of sodium cyanide to zinc metal is maintained at 2.75.

Contamination of the bath is caused by the formation of carbonates and dissolving of certain metals. Carbonates, formed as the result of a reaction between the plating bath and air, build up very slowly and are removed at infrequent intervals. This is done by adding hydrated lime to produce insoluble calcium carbonate which is precipitated, washed to recover soluble cyanide, and dumped.

Metal impurities usually occur as lead or cadmium, small amounts of which can seriously affect the appearance and corrosion resistance of the zinc plate. Analysis of the solution is made each day to determine the presence of such contaminants. These are precipitated as metal sulphides by small additions of polysulphide and are subsequently filtered out of the solution.

Nominal operating temperature of the bath is 90° F., this being maintained by automatic steam regulators in the feed line to the heating coils in the plating tank. Poor quality work is sometimes encountered even though current density, solution composition and temperature are under control. The cause is usually traceable to the workholders. Misalignment of the workholders, worn or improperly adjusted electrical

contacts (which also support the cases) or corroded conveyer arms or hangers for workholders are the most common sources of trouble. Periodic inspection and repair is the most satisfactory way of preventing such difficulties.

Because drag-out of the plating solution on the work and workholders is substantial, a tank is provided into which the excess can drip. The reclaimed solution is returned to the zinc plating tank as it accumulates.

The plated articles move to a reclaim rinse which removes most of the plating solution remaining on the work and the workholders. This rinse water is pumped into the plating tank at the end of each shift to partially replace the losses by evaporation. Following this are two more rinses, both in tanks having top sprays to provide maximum rinsing action.

The plating machine can apply a chromate conversion film to the zinc plated surface either by an acidified dip (Cronak) or by electrolytic action (Anozinc). As presently operated, the Anozinc process is employed.

Application of Anozinc

The process for the zinc chromate conversion film utilizes proprietary chemicals made by United Chromium, Inc. Concentration of the process solution is measured by specific gravity determinations and by titrations with an alkaline reagent. Close control is also maintained over the pH of the solution (5.5 to 6.0). The work is made anodic for the electrolytic deposition of the Anozinc film.

Thickness of this film is directly proportional to the current density since the other factor, du-



Fig. 3 - Automatic Plating Machine as Seen From the Plating Tank End. The J-shaped zinc plating tank is at the center of the illustration and the various plating solution processing equipment is in the foreground. Note extensive ventilating duct system for disposing of noxious fumes

ration of exposure, is constant (being determined by the dwell cycle of the machine). Current density is maintained between 10 and 15 amp. per sq.ft. of work surface. Appearance and adherence of the film also are functions of the current density. Low density will produce very pale, iridescent films; excessively high density will yield deep yellow, nonadherent coatings.

Top sprays are used with the first of the two final rinses, air jets with the second rinse to blow off the pool of water from the head surface of the work. This promotes drying of the cases in

the next operation, in which air that has been heated to about 150° F. is discharged through $\frac{1}{2}$ -in. diameter jets against the external surfaces of the cases. Their interiors are dried by air that is conducted through the workholder inert anode to the inside of the cartridge case. The warmed air is recirculated to the blower.

Automatic Plating Machine

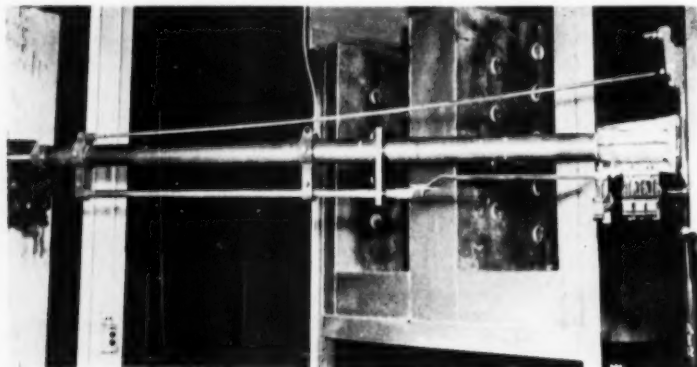
The equipment required to perform the operations shown in Table I is quite extensive and complex, so only a brief description of its more general components can be attempted in this article. Work is moved through all of the cycles of the Hanson-Van Winkle-Munning plating machine by an elevator or "jack rabbit" type conveyer which has a vertical lift of 54 in. and a forward transfer of 36 in. during

each cycle. Two separate drive systems are provided, one for operation of the elevator lifting mechanism, and the other for operation of the forward transfer.

Transfer time, including lift, forward transfer, and drop of the conveyer, is 34 sec. Dwell at the end of each transfer (with conveyer in lowered position) is adjustable between 0 and 120 sec. and is set for 11 sec. dwell for plating of the 5-in. 38-caliber cartridge cases. Unit cycle time is equal to dwell plus time for transfer, in this instance 45 sec., and is the controlling factor in the production rate.

The conveyer is equipped with 50 copper carrier arms extending outward from the central structure which supports the conveyer and the mechanism for the conveyer drive. The purpose of the carrier arm is to support workholders carrying the work and to conduct the electric current from busbars to the workholders. Each arm is of bipolar construction consisting of a large weight-carrying member to which a smaller mem-

Fig. 4 - Conveyer Arm Showing Bipolar Construction and Electrical Pickups for Making Contact With Busbars



ber is attached by means of insulated couplings as shown in Fig. 4.

Each member of the conveyer arm is equipped with sliding-shoe electrical contacts which make up the electrical circuit with busbars mounted on the central structure. Current to the busbars is supplied by motor-generator sets for the zinc plating operation, and by individual rectifier units for each of the electrolytic cleaning operations and for application of the Anozinc.

Two bipolar workholders are suspended from each conveyer arm. The workholder (Fig. 5) is constructed of two copper bars, the right angle ends of which are insulated from each other by a Teflon gasket, and the open ends of this U-shaped framework are formed into hangers. Two copper bars are brazed crosswise to the framework, one to each side of the insulated connection. A nickel yoke is attached to both ends of one of these crosspieces. Two bronze electrical contacts (which also support the cartridge case) are threaded into the nickel yoke. An Inconel tube, which serves as an internal inert electrode during zinc plating, is attached to each end of the second crosspiece and extends through the yoke and upward inside the steel cartridge case.

A Teflon insulator and the rack coating material prevent short circuiting between the yoke and the electrode. With the exception of the electrical contacts and the internal electrode, the workholder is coated with approximately $\frac{1}{8}$ -in. thick vinyl resin protective material (Belke No. 570).

Each workholder holds two cartridge cases which are placed mouth down over the internal electrode. This position causes an air bubble to be trapped inside the head of the case between the primer boss and the sidewall that would prevent processing that portion of the case. To correct this difficulty the bottom of the electrode has a funnel (Fig. 6) which collects processing solution from vertical jets suitably located in horizontal manifolds in the bottom of the processing tanks. The collected processing solution is forced through the hollow electrode and out the top. A double-cone head (with spiral-shaped vanes between the cones) at the top of the electrode directs this solution into the air pocket inside the cartridge case head and imparts a swirling action which displaces the air bubble so that all surfaces are subjected to the processing solutions.

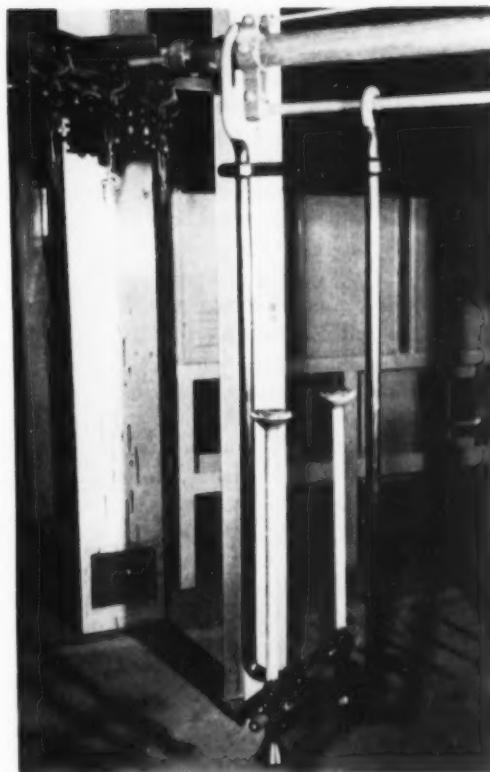
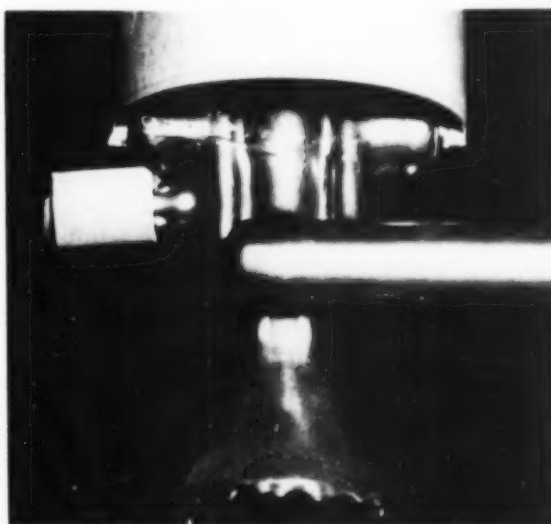


Fig. 5 - Conveyer Arm, Workholder, and the Two Inert Anodes. Anodes have double-cone construction at top

Fig. 6 - Method of Supporting Cartridge Case on Electrical Contacts of Workholder. The cone at base of workholder collects processing solution from manifolds located at the bottom of the processing tank



Various types of contact points which support the case and make electrical contact with the case through the workholder have been used. The most successful of these provides a tapered surface. The contacts are positioned so that the mouth of the case rests upon the tapered surface but will not slip down over the lower edge of the contact points, as shown in Fig 6.

An insulated locating pin projects from the top of the internal electrode and extends through the primer hole of the cartridge case to centralize the case with respect to the electrode, thereby promoting even current density to obtain uniform thickness of the zinc plate in the internal surfaces of the case.

The electrical requirements are supplied by Hanson-Van Winkle-Munning rectifiers and motor-generator sets. Rectifiers are used to supply current for the electrolytic cleaning operations and for application of the Anozinc. The rectifiers are the selenium type with variable voltage output from 0 to 15 volts, and a maximum current output of 4000 amp.

Current for the zinc plating operation is supplied by two motor-generator sets, one having an output of 12,500 amp. for the external plating circuit and the second a capacity of 7500 amp. for the internal circuit. Voltage output is variable from 2 to 10 volts.

In each of the above operations, two electrical circuits are required, one for processing the internal surface of the work, and the other for the external surfaces. When placed in position on the workholder, the steel cartridge case becomes one of the electrodes for both circuits.

The polarity of the case will depend upon the requirements of the operation. In the first electrolytic cleaning operation and in zinc plating, the work is cathodic. It is anodic in the second electrocleaner and Anozinc sections. The electrodes of opposite polarity to that of the case consist of the internal inert electrode of the workholder for the internal circuit, and flat mild steel plates suspended from busbars along the edge of the processing tanks for the external circuit. In the zinc plating tank, the external circuit electrodes consist of coiled-wire baskets suspended from the busbars and filled with cast balls of high-purity zinc.

A system of sprays is available when additional rinsing is required. These water sprays are located above the work so that as it is removed from the rinse tank external surfaces are washed down. Drying is speeded by air blow-off jets mounted on the side of the tank so that the air


blast will remove the pool of water which collects on the heads of the cases as they are withdrawn from the rinse tank.

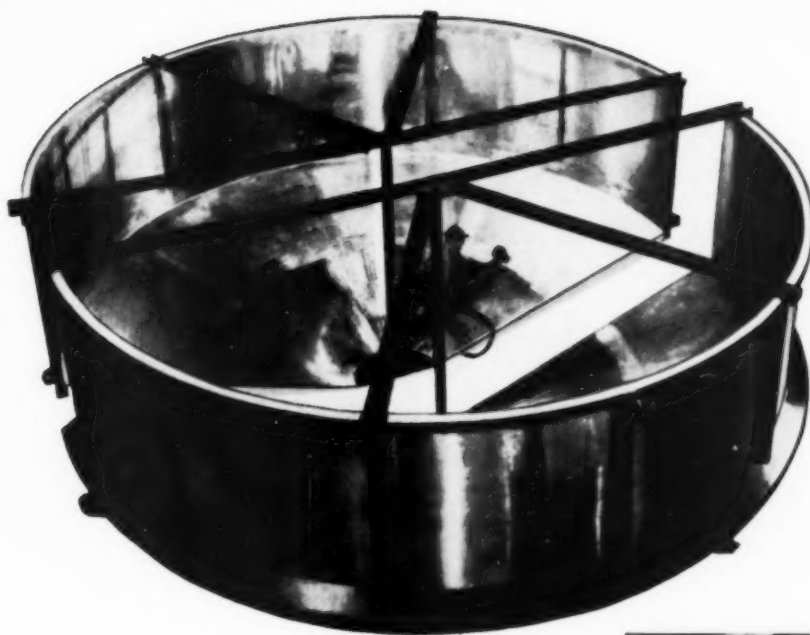
Disposal Systems—Considerable quantities of solutions containing acid, caustic, chromates and cyanides must be disposed of. Experience has shown that all solutions, other than those containing cyanides, can be safely collected and treated together.

Each processing tank is equipped with overflow weirs which maintain the maximum solution level approximately 3 in. below the top of the tank. Solution which flows over the weir is collected in a discharge line that empties directly into a brick-lined gutter. Floors adjacent to the processing area are sloped so that spillage of processing solutions may be easily flushed into the gutters.

The gutters discharge into 36x36-in. sand traps with Duriron sewer pipe outlets which feed into a plant-wide collection system for acid effluents. This in turn discharges into a collection well where the solution is processed automatically to neutralize any acid or alkali. The neutralized effluent is then pumped to large settling beds where dry precipitated solids are removed and the clear effluent is discharged into an adjacent river. The effluent must meet very stringent antipollution standards.

In the zinc plating section and adjacent cyanide solution filtering and draining areas, the floors are sloped to drain into a separate system of gutters and sumps. The cyanide-bearing solutions are discharged into a special sewer system to a cyanide destruction plant. Here the cyanide solutions are continuously and automatically treated with chlorine (in Wallace and Tiernan equipment) to completely destroy all cyanides. The cyanide-free effluent is discharged into sumps together with the neutralized acid effluent.

Conclusion—Individually, the chemical processes involved are neither unique nor complex, but collectively, the breakdown of any single chemical processing operation can be responsible for the failure of the unit as a whole. Furthermore, the mechanical accomplishment of these chemical processes is quite complicated and introduces a multitude of possible sources of breakdown or malfunction. Attention to concentrations and purity of processing solutions, operating temperatures and maintenance of the equipment is essential for the production of a satisfactory zinc plate as well as to obtain the maximum efficiency of the equipment. 



75 Tons of Type 304 Stainless Steel were fabricated for the new Anheuser-Busch West Coast brewhall. Note size of this starting tank, by comparison with workman polishing it at plant of Nooter Corp., St. Louis, Mo.

New Method of Supporting Brewing Tanks, devised by Nooter engineers, provides superior stability and performance. Eliminating usual costly complicated under framing. Nooter suspended three from floor beams of the plant itself, and rested others on steel legs sunk deep into concrete beams in the floor.

All Stainless Steel

**Brewhall of Anheuser-Busch
Cuts Maintenance and
Promotes Product Purity**



The new Anheuser-Busch brewery in California's San Fernando Valley is a man-made beauty...

It's the nation's first brewhall built to an integrated design, with all equipment of lustrous chromium-nickel stainless steel.

Easy to clean and keep clean, it helps assure product purity in all divisions of the food and beverage industries. That is why Anheuser-Busch selected chromium-nickel stainless with its invaluable protection against corrosion, year-after-year. The smooth, silvery-white surface of the Type 304 stainless steel allows no harbor for contaminants,

no chance for product impurity.

For other industries with different demands, it provides unusual strength at elevated temperatures, yet, in sub-zero service it possesses enviable toughness. It resists wear and has other useful properties. And, of course, it readily responds to all usual forms of fabrication, including welding.

Use chromium-nickel stainless to *improve your products*. Leading steel companies produce these austenitic alloys in all commercial forms. A list of sources of supply will be furnished on request.



THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET
NEW YORK 5, N.Y.

New Numbering System for Wrought Aluminum Alloys

Adopted by the Aluminum Assoc., Oct. 1, 1954

Alloys are designated by a four-digit index system similar to the S.A.E. numbering system for steels. The first digit indicates the alloy group as shown in the tabulation alongside. The last two digits identify the particular alloy or indicate the aluminum purity. The second and third digits indicate alloy modifications or impurity limits.

Aluminum—In the 1xxx group for 99.00% min. aluminum the last two digits indicate the minimum aluminum percentage to the right of the decimal point. The second digit indicates modifications in impurity limits. If the second digit in the designation is zero, it indicates that there is no special control on individual impurities; while integers 1 through 9, assigned consecutively as needed, indicate special control of one or more individual impurities.

Thus, 1030 indicates 99.30% minimum aluminum without special control on individual impurities, and 1130, 1230, 1330 indicate the same purity with special control on one or more impurities. Likewise 1075, 1175, 1275 indicate 99.75% minimum aluminum; and 1097, 1197, 1297 indicate 99.97%.

Designations for Alloy Groups

Aluminum — 99.00% minimum and greater	1xxx
Major Alloying Element — Copper	2xxx
Manganese	3xxx
Silicon	4xxx
Magnesium	5xxx
Zinc	6xxx
Other element	7xxx
Unused Series	8xxx
	9xxx

Aluminum Alloys—In the 2xxx through 8xxx alloy groups the last two digits have no special significance except to identify the alloy. Generally, these digits are the same as those formerly used to designate the same alloy. Thus, 2014 was formerly 14S, 3003 was 3S, and 7075 was 7S. For new alloys these last two digits are

assigned consecutively beginning with xx01. The second digit in the designation indicates alloy modifications. If the second digit is zero, it indicates the original alloy; while integers 1 through 9 which are assigned consecutively, indicate alloy modifications. In the former system letters were used to designate alloy modifications. These were assigned consecutively beginning with A. Thus 17S is now 2017 and A17S is 2117, 18S is 2018 and B18S is 2218.

Experimental alloys are indicated by the prefix X. The prefix is dropped when the alloy becomes standard. During development, and before they are designated as experimental, new alloys are identified by serial numbers assigned by their originators. Use of the serial number is discontinued when the X number is assigned.

Temper Designations—The temper designation system in effect since Dec. 31, 1947, is being continued without change. The temper designation follows the alloy designation and is separated from it by a hyphen. Thus 3S-O is now 3003-O. Alclad 24S-T61 is Alclad 2024-T81, and 75S-T6 is 7075-T6.

Conversions, New to Old

NEW	OLD	NEW	OLD
EC*	EC	18S	B4S
1030	AE1S	2018	XC56S
1050	AD1S	2025	C57S, K157
1060	BD1S	2117	XD50S
1070	AC1S	X2214	F52S
1075	BC1S	6003††	R306, K162
1080	BC1S	6061	B25S
1085	AB1S	6061	.61S
1090	FB1S	6062	.62S
1095	AA1S	6063	.63S
1099	BA1S	6066	.66S
1100	2S	6151	.A1S
1130†	R308	X6251	XB51S
1145	BE1S	6253	.B3S
1150	ED1S	X6453	XD53S
1160	CD1S, 99.6	6553	E53S
1175†	.99.75	X4543	.J51S, K160
1180	CC1S, R998	5005	A50S, R305, K155
1187	EB1S, 99.87	5050	.70S
1197	CA1S	5052	.52S
1230**	99.3	X5055	X55S
1235	R993	5056	.56S
2011	.11S	5083	LK163
2014	.14S, R301 Core	5086	K166
2017	.17S	5154	.A54S

*EC (the designation for electrical conductor metal) is not being changed since it is so firmly established in the electrical industry.

†No. 1 Reflector Sheet.

‡Cladding on No. 2 Reflector Sheet. **Cladding on Alclad 2024 (Alclad 24S).

Conversions, Old to New

OLD	NEW	OLD	NEW
99.3**	1230	17S	2017
99.6, CD1S	1160	A17S	2117
99.75†	1175	18S	2018
99.87, EB1S	1187	B18S	2218
EC*	1187	F18S	2618
AA1S	1095	24S	2024
BA1S	1099	25S	2025
CA1S	1197	B25S	2225
AB1S	1085	32S	4032
EB1S	1187	43S, K145	4043
FB1S	1090	C43S, 44S, K143	4343
AC1S	1070	XA78S	7277
BC1S	1080	XB80S	X7178
CC1S	1180	K112	X8280
CC1S	1180	K143	8112
CC1S	1075	K143, C43S, 44S	4343
AD1S	1050	K145, 43S	4043
BD1S	1060	K155, A50S, R305	5005
CD1S	1160	K157, C57S	5357
ED1S	1150	K160, J51S	6951
AE1S	1030	K162, R306††	6003
BE1S	1145	LK183	5083
2S	1100	K186	5086
3S	3003	R301 Core, 14S	2014
4S	3004	R305, K155, A50S	5005
XA5S	X3005	R306, K162††	6003
11S	2011	ED53S	6553
14S, R301 Core	2014	X53S	5353
XB14S	X2214	A54S	5154
XC16S	X2316	B4S	5086
		X55S	5555

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY



1 . . 5 . . 10 . . 15 . . 20 . . 25 . . 30 . . 36

YES, **36** CONSECUTIVE YEARS
AS USUAL, AT THE MAIN ENTRANCE OF THE
NATIONAL METAL EXPOSITION
GENERAL ALLOYS COMPANY, BOSTON, MASS.

"OLDEST AND LARGEST EXCLUSIVE MFRS. OF HEAT & CORROSION RESISTANT CASTINGS"

**BRANCH
OFFICES
AND
REPRESENT-
ATIVES**

BALTIMORE, Maryland
Emil Gathmann, Jr.
513 Park Avenue

BUFFALO, New York
Roy E. Lynd
812 Tacoma Ave.

BIRMINGHAM, Alabama
Ray F. Frings
Harry G. Mount
1247 American Life Bldg.

CHICAGO, Illinois
General Alloys Company
Edward T. Connolly
224 S. Michigan Ave.

CLEVELAND 15, Ohio
E. E. Whiteside
2254 Euclid Ave.

DENVER, Colorado
Tracy G. Jarrett
95 S. Ammons St.

PHILADELPHIA, Pa.
John P. Clark Co.
124 S. Easton Road
Glenside, Pa.

DETROIT 2, Michigan
General Alloys Company
Don B. Hutchins
3-147 General Motors Bldg.

FORT WAYNE 8, Indiana
The George O. Desautels Co.
P.O. Box 1178
R.R. 11, No. Bend Drive

HOUSTON 3, Texas
Wm. E. Brice Co.
1512 Pease Ave.

PITTSBURGH 15, Pa.
Vincent C. Leatherby
400 So. Main St.
Sharpsburg 15, Pa.

LOS ANGELES, California
Davis-Gregg Company
406 S. Main Street

LOUISVILLE 7, Kentucky
The George O. Desautels Co.
4033 Hycliffe Avenue

INDIANAPOLIS 8, Indiana
The George O. Desautels Co.
2302 N. Meridian Street
P.O. Box 7011

ST. LOUIS 10, Missouri
Associated Steel Mills, Inc.
3163-65 Morganford Road

MUNCIE, Indiana
The George O. Desautels Co.
P.O. Box 776
103 Wyster Block

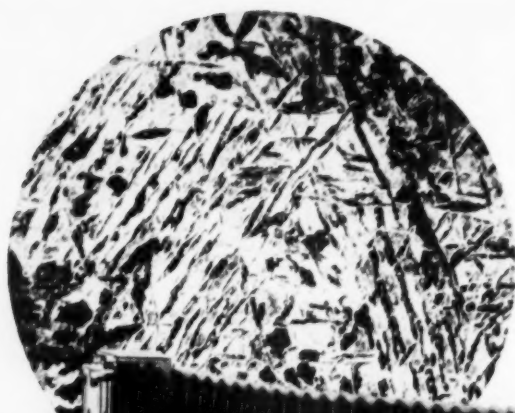
NEW ENGLAND
David L. Ellis
Woodland Road
West Concord, Mass.

NEW YORK 7, New York
General Alloys Co.
Alfred M. Sampler
50 Church Street

QALLOYS

THE QUALITY NAMES IN ALLOY
FOR HEAT CORROSION ABRASION

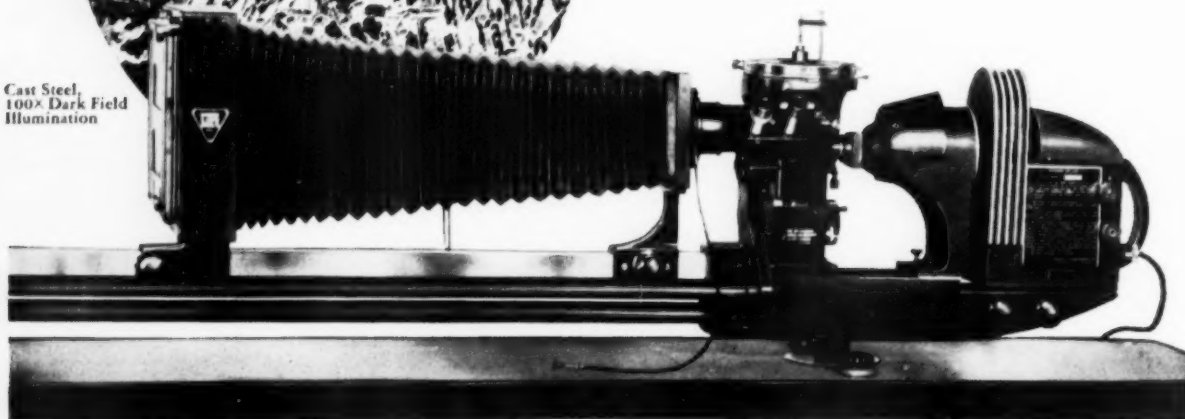
X-ite



Cast Steel,
100× Dark Field
Illumination

SPEEDS PRODUCTION

by simplifying analysis of "hard-to-see" structure



There's an efficient solution to your metallurgical problem in this complete Bausch & Lomb line:

- Four different metallographs, ranging in use from routine bright field studies to advanced research. (Catalogs E-28, E-29, E-232, E-240)
- Photomacrographic Equipment Model L . . . widest low power range. (Catalog E-210)
- CM Metallurgical Microscope . . . industry's standard. (Catalog E-223)
- Stereomicroscopes . . . vivid 3-dimensional low power studies. (Catalog D-15)
- Eyepiece Camera . . . 35mm or 2 1/4" x 3 1/4" film. (Catalog E-244)
- Polaroid Land Camera Attachment . . . finished print in one minute! (Catalog E-243)

Bausch & Lomb Research Metallograph

. . . Metal industry's maximum use instrument . . . helps you boost output and maintain quality by providing clear, detailed magnified images—visual or photographic—for routine work and advanced research.

You see samples better because exclusive Balcoted objectives bring out detail even in low contrast specimens. *You're sure of complete identification* because you have your choice of four different views of the same sample—by bright field, dark field, polarized light, or phase contrast; change-over is quick and simple.

There may well be considerable savings of time and materials for your company in these faster, easier, completely dependable analyses. Why not find out now? Write for Catalog E-240.

WRITE or PHONE for complete information (specify catalog numbers) and for prompt, expert advisory service. No obligation, of course. Bausch & Lomb Optical Co., 63833 St. Paul St., Rochester 2, N. Y. Phone: LOcust 3000.

BAUSCH & LOMB



METALLURGICAL EQUIPMENT

Aluminum in France

*Reported by T. L. FRITZLEN **

Meetings, exposition and plant visitations in a centenary celebration of Deville's production of aluminum metal, show that the French use of aluminum in automobiles (consuming one fifth the total output) is on a much greater scale than in America.

TO COMMEMORATE the centenary of the world's first production of aluminum by Sainte-Claire Deville a scientific congress in Paris, June 14 to 19, was arranged by the Société Chimique de France and L'Aluminium Français under the patronage of the president of the French Republic. The Société Chimique de France counted Deville as one of its presidents. A formal session was held at the Sorbonne wherein several addresses concerned Deville's scientific work and its industrial consequences.

Some 75 papers were presented at other sessions held at Maison de la Chimie ranging over a wide field: properties of the metal and its compounds, production, analytical procedures, alloying, surface protection, fabrication and applications. In these meetings the language difficulty—never met in metallurgical conferences here—was handled most efficiently. Summaries of the papers were presented in the author's language and simultaneously translated into French, German and English, with reception obtained by radio earphones tuned into the proper channel. Discussion was handled similarly. The proceedings will be published in full by the International Scientific Congress.

As stated, this gathering commemorated the 100th anniversary of an event which attracted no great amount of attention at the time. In 1851, Henri Sainte-Claire Deville, who at the age of 33 was head of the Chemistry School in Paris, interested Napoleon III and the French Academy of Science in his ideas for reducing the double salt of sodium-aluminum chloride by sodium amalgam. Three years later, in February and August, 1854, the results of his work were communicated to the Academy. His chemical method was developed in France with little delay, and

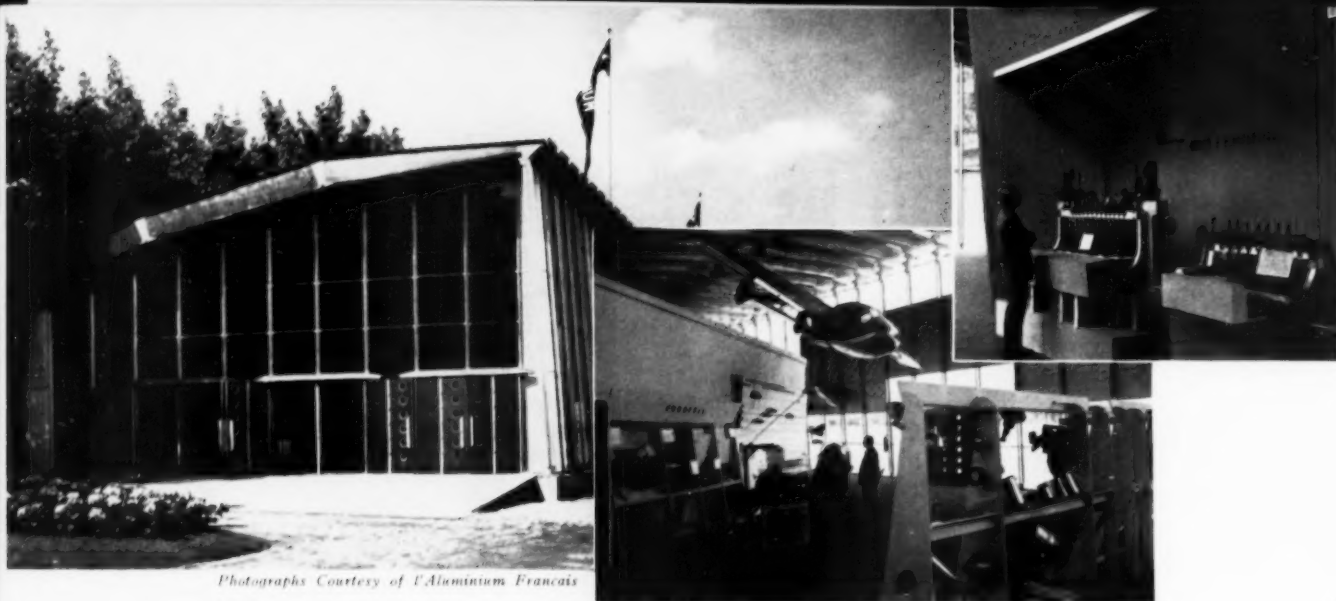
the first aluminum of 96 to 97% purity was produced in Nanterre, a suburb of Paris. It cost £53 sterling per lb. (at least \$1000.00 in 1954 dollars). The price per pound had dropped to £3, 12 shillings (about \$70.00, 1954 dollars) in 1880, yet this high price clouded any prospects for the widespread application of aluminum in the industrial field, as predicted by the inventor.

Sainte-Claire Deville also presented a small ingot of pure aluminum to the French Academy of Science that same year (1854), which he had produced by igneous electrolysis. However, the lack of a cheap and abundant source of electrical power prevented the further development of his method. The construction of the first industrial electrical generator by Gramme in 1872, and the simultaneous discoveries of Hall and Heroult in 1886, resulted in the production of aluminum by electrolysis, the abandonment of the chemical method, and the fulfillment of Deville's early prophecy that aluminum could be developed into a useful metal.

Just how useful aluminum is, today, hardly needs to be specified to an audience of metallurgists. However, even a specialist could not help but be interested in the exposition held simultaneously with this commemoration by L'Aluminium Français†. An outstanding feature

*Chief Metallurgist, Reynolds Metals Co., Richmond, Va.

†The Centre Technique de L'Aluminium in Paris serves to study and develop new uses for aluminum, to provide technical advice on the proper alloys to use and how to use them. As a technical center, it functions under the joint sales organization, L'Aluminium Français, which in turn is supported by the two companies producing primary aluminum, Compagnie Pechiney and Société d'Electro-Chimie d'Ugine.



Photographs Courtesy of l'Aluminium Français

Fig. 1—The Aluminum Exposition Was Held in a Demountable Aluminum-Glass Building on the Left Bank of the Seine in Paris. Fig. 2—Details of the Building Can Be

Seen in the Interior Above—Also Informal and Attractive Displays of Work-a-Day Items. Fig. 3 (Upper Right)—Fifth-Scale Models of 100,000 and 50,000-Amp. Reduction Cells.

was the building itself which housed the exhibits—all aluminum and glass, 50 ft. wide by 492 ft. long. The main facade, facing the river, is 25 ft. high, and the rear wall is 18 ft. The slightly arched, self-supporting roof is made up of U-shaped girders 16½ ft. long, formed from 0.156-in. alloy plate, spliced at third points and fixed at ends into pressed fittings. Tubular posts were formed from similar sheet into two sections, spot welded together. Aluminum roofing sheets covered the girders and were hooked onto them. Side plates and panels of aluminum sheet were fixed by clips fitted into grooves in the facade posts. Figure 1 shows the outside of this exposition building and the exterior construction. Note how the fact that the site is a stone-paved quay does not exclude a bed of glowing flowers. An idea of the interior construction and display arrangements can be had from Fig. 2. Semi-finished products, finished articles and fabricating operations were on exhibit. Figure 3 shows fifth-scale models of vertical-pin 50,000 and 100,000-amp. cells for electrolytic reduction. Operations such as melting, die casting, induction heating, impact extrusion, foil printing, anodizing, welding, sonic testing and spectrographic analysis were performed in working exhibits, even to a 1000-ton Loewy press extruding an aluminum shape.

This aluminum exhibition disclosed considerably more application of aluminum to the automotive industry, proportionally, than in the United States. Between 20 and 25% of France's

total consumption of aluminum goes into the automotive industry; this in contrast to an estimated 5% or less to automotive uses in the United States. The high cost of gasoline in France makes the weight of the automobile an important economic factor. For example, the Dyna-Panhard, designed to use aluminum to the greatest extent, weighs 1323 lb. as against 2205 lb. for competitive cars of similar size. The Dyna has a two-cylinder, air-cooled engine said to be capable of a maximum speed of 80 miles per hr. with full load, an acceleration from stop to 50 miles per hr. in 10 sec., and an average gas consumption of 40 miles per gal. The writer toured southeastern France in a new Dyna-Panhard, and the way it performed through village and countryside convinced him that the claims for maximum speed and acceleration are easily met.

During this trip a visit was made to the Isoire Works of Cegedur (aluminum rolling mill) and Compagnie Pechiney works at Saint-Jean de Maurienne (reduction plants) in central and southeastern France, in company with about half of the 476 registrants of the Congress. Outstanding developments observed in these visitations were the operation of an induction furnace for continuously heat treating aluminum alloy strip (described in *Metal Progress* for October 1951) and the vertical-pin 100,000-amp. cells of Söderberg design for aluminum reduction.

Henri Sainte-Claire Deville was a prophet when he said, in 1854, that aluminum could be developed into a useful metal. ☼

Induction Surface Hardening of Ductile Iron

By JOSEPH F. LIBSCH and JOSEPH C. DANKO*

Ductile or nodular cast iron, heat treated by quench and temper or isothermally to a structure containing considerable combined carbon, can be case hardened by rapid induction or flame heating to about C-57, with case depths somewhat greater than for steel.

RECENT publications on ductile iron have reported mechanical properties which offer many interesting engineering possibilities. Among these possibilities is that it may be surface hardened. A hard surface supported by a ductile core of good strength may provide a unique combination of properties for iron castings. While considerable variation in the mechanical properties in the as-cast state may result from changes in analysis and production techniques, maximum variation is achieved by heat treatment. The ductility may be increased progressively by either of two methods — (a) heating the casting to the 1600 to 1700° F. range followed by isothermal transformation at 1100 to 1300° F., or (b) rapid cooling from 1650 to 1700 and tempering at 1100 to 1300° F. The increase in ductility with increased time and temperature of isothermal transformation or of tempering is basically related to a progressive increase in the ratio of ferrite to pearlite in the microstructure, and is accompanied by a continuous decrease in yield and tensile strength. It is thus possible to select various combinations of mechanical properties deemed desirable as core properties in surface hardened sections.

Case hardening of cast iron requires a rapid heating of the surface with such techniques as induction and flame heating so very little heat penetrates to the interior. Unfortunately, rapid heating gives a minimum of time for carbon to diffuse and form reasonably homogeneous austenite prior to quenching. Successful surface

hardening therefore depends upon the structure prior to case hardening.

Suitable prior structures of ductile iron consist of ferrite, secondary carbide (pearlite or other fine mixtures of ferrite and carbide) and graphite spheroids. However, the distribution of these microconstituents may vary extensively, depending upon prior heat treatment — quenching and tempering or isothermal transformation. The ultimate structure for either extended tempering or long isothermal treatment is a fully "ferritized" structure consisting only of ferrite grains and spheroidal graphite (spherulites).

In practice, castings for isothermal treatment are heated to 1600 to 1700° F. for 1 to 2 hr., then cooled rapidly to a temperature between 1100 and 1350° F. and held for a time which depends upon the time-temperature-transformation curve and the rate of ferrite formation. Figure 1 gives TTT-curves for two heats of ductile iron principally varying in their silicon content, Heat N (2.98% Si) and Heat K (1.87% Si). Complete analyses are given in Table I.

The wide variation in possible microstructures is illustrated by three insets selected from a more complete presentation by E. P. Rowady, W. J.

*Dr. Libsch is professor of metallurgy and Mr. Danko is research fellow and instructor at Lehigh University, Bethlehem, Pa. Dr. Libsch is also consulting metallurgist to Lepel High Frequency Laboratories of New York City. The International Nickel Co. sponsored the work described, so the term for the material preferred by that company — ductile iron — is used in this article.

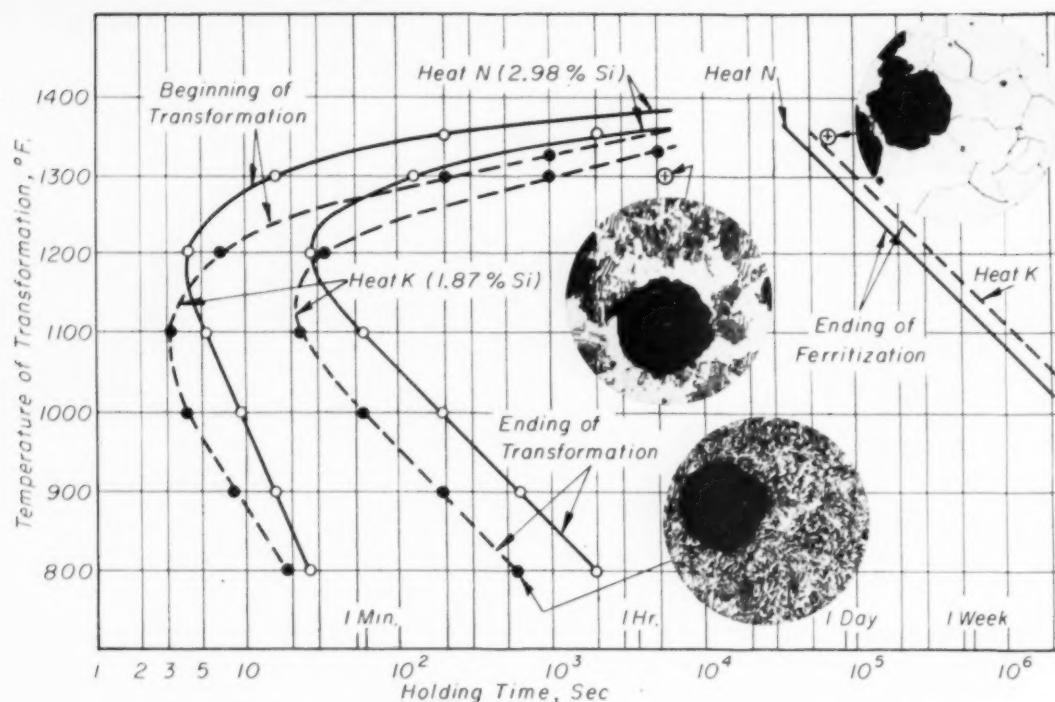


Fig. 1—TTT-Curves for Heat N (2.98% Si) and Heat K (1.87% Si), Both Austenitized at 1600° F. Partially ferritized structure of Heat

K (1300° F., 1.5 hr.); totally ferritized structure of Heat N (1350° F., 16.5 hr.); acicular structure of Heat K (800° F., 10 min.) at 200 ×

Murphy and J. F. Libsch before the 1953 meeting of the American Foundrymen's Society. The products of transformation at 1300° F. consist of coarse pearlite, ferrite and spheroidal graphite. Increased time at elevated temperature causes gradual decomposition of the secondary carbide to produce a completely ferritized structure. As the temperature of isothermal transformation decreases, the pearlite spacing becomes progressively smaller and the time for ferritization rapidly increases. The metallic matrix that forms below the nose of the isothermal transformation diagram (below 1000° F.) is predominantly acicular in nature.

Table I—Composition of Heats Studied

ELEMENT	HEAT K	HEAT L	HEAT M	HEAT N
Total carbon	3.42%	3.24	3.47	3.49
Silicon	1.87	2.06	3.10	2.98
Manganese	0.32	0.73	0.78	0.34
Nickel	0.75	0.63	0.83	0.83
Phosphorus	0.034	0.020	0.034	0.034
Sulphur	0.01	0.016	0.01	0.01
Magnesium	0.076	0.063	0.062	0.056

The mechanical properties of isothermally transformed structures vary in a continuous manner with temperature and time, the range of properties varying from 134,000 to 52,600 psi. for tensile strength, 4 to 20.6% elongation, and 26 to 70 ft.-lb. for impact resistance (unnotched Charpy) in Heat K, a low-silicon (1.87%) low-manganese (0.32%) heat.

Quenched and tempered castings are oil quenched from 1600 to 1700° F. Tempering is in the 1100 to 1300 range for one or more hours. The influence of tempering temperature upon structure for Heat K is shown in Fig. 2. Note the finely dispersed acicular ferrite-carbide aggregate at 1100° F. (Fig. 2, left), the partially ferritized structure at 1200° F. (Fig. 2, center) and finally a structure consisting of equiaxed grains of ferrite plus large primary and tiny secondary graphite spheroids at 1300° F. (Fig. 2, right). The secondary graphite is typical of quenched structures tempered at 1100° F. or above.

The mechanical properties of the quenched and tempered structures generally vary in a continuous manner with tempering tempera-

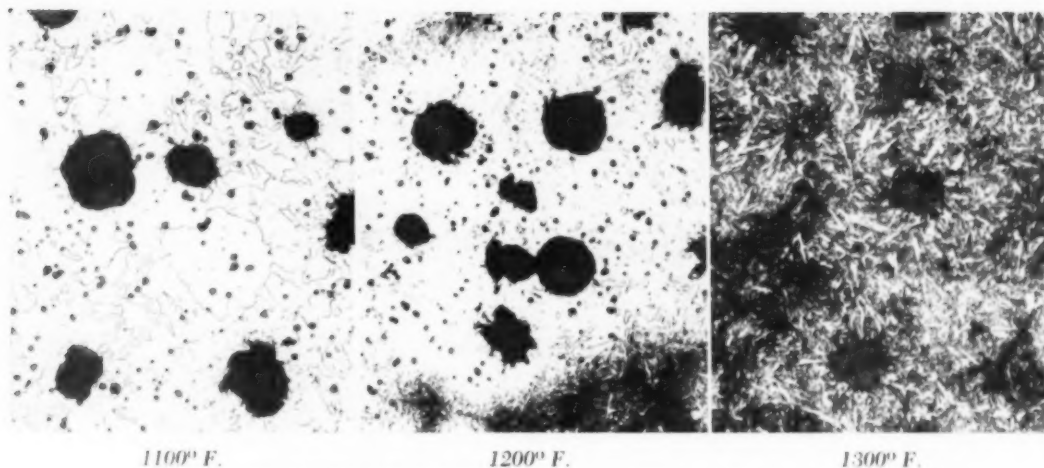


Fig. 2—Heat K, Oil Quenched From 1650 and Tempered 2 Hr. at Temperatures Shown. Picral-nital etch. 250×

ture as illustrated by Fig. 3 for Heat N. The discontinuity in the tensile strength curve shown at tempering temperatures of 1100°, typical of all heats studied, seems to be associated with the change from acicular to equiaxed ferrite and the appearance of secondary graphite.

It thus appears that quenched and tempered structures also provide a wide range of properties for selection of core properties in a case hardened section.

Hardening Response

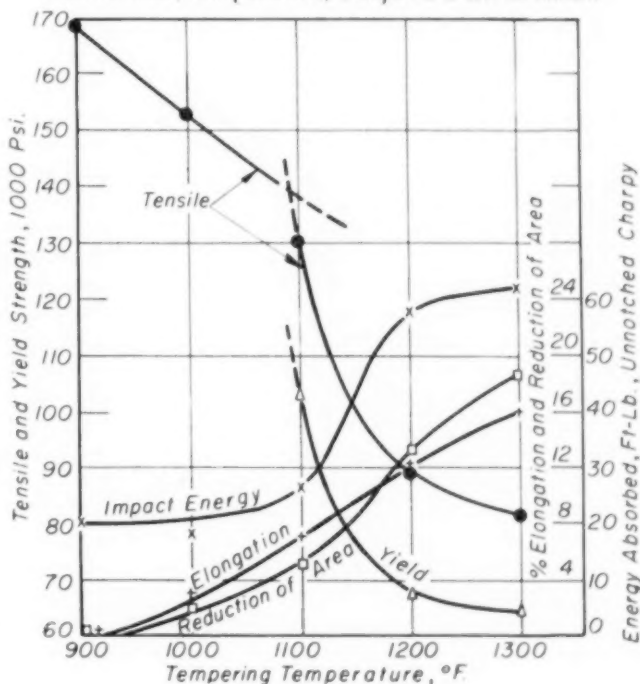
The martensitic hardness of unquenched engineering steels and cast iron depends upon the carbon in solution in the austenite at the time of quenching. It has been well established that iron carbide has time to dissolve readily in austenite during conventional induction hardening cycles, but that graphite enters solution but slowly. However, both dissolve faster as temperature goes up. Thus it might be expected that the combined carbon (carbide content) would play a major role, and that graphitic carbon might become important only as either the hardening temperature or soaking time was increased.

This influence of prior structure upon the induction hardening characteristics of ductile iron is well illustrated in the three diagrams of Fig. 4. The test pieces were oil quenched from 1650° F. and tempered for 2 hr.

at 1100, 1200 and 1300° F. respectively. Microstructures were similar to those shown in Fig. 2. It is apparent that the surface hardness after heating to 1600° F. and quenching in water (top diagram of Fig. 4) varies significantly with both prior structure and time at 1600° F.

For conditions leading to a minimum case depth the results presented for zero time are

Fig. 3—Mechanical Properties of Heat N, Austenitized 1 Hr. at 1650, Oil Quenched, Tempered 2 Hr. as Shown



most significant, for they represent quenching immediately upon reaching 1600° F. It took only 3 or 4 sec. to reach temperature. As the amount of combined carbon (carbide in the prior structure) decreases, the response to induction heating decreases. Only the structure formed by tempering at 1100° F. would provide reasonable surface hardness by heating to 1600° F. It is interesting to note, however, that even the material essentially ferritized (1300° F., 2 hr.) may develop satisfactory hardness in the remarkably short period of 30 sec.

The influence of prior structure can be largely overcome by increasing the induction hardening temperature as is shown in the middle diagram of Fig. 4. Apparently raising the hardening temperature to 1700° F. has provided successful response for all prior structures.

However, excessive hardening temperatures not only increase the case depth but may retain substantial amounts of austenite in the quenched structure. Thus, induction heating to 1800° F. (bottom diagram of Fig. 4) causes a progressive decrease in hardness with time at temperature. Subzero cooling experiments demonstrate that most of this loss is associated with retained austenite in the hardened structure. High-manganese heats (0.78%) are particularly affected by high hardening temperatures.

Although the above data pertain to quenched and tempered castings, isothermally transformed structures behave similarly. As the amount of ferrite and the coarseness of the pearlite in the prior structure increase, the response to induction heating decreases.

Selection of the prior microstructure for induction surface hardening should then be guided primarily by the properties desired in the core. Where the ductility desired does not exceed 3 to 6% elongation, the prior structure provides almost immediate response to induction surface hardening, and little attention need be accorded the hardening cycle. When intermediate ductility is required—about 8 to 12% elongation—the prior structure becomes important and the induction hardening temperature and case depth may have to be increased to provide suitable response. Completely ferritized structures with maximum ductility (18 to 22% elongation) are generally unsuitable for surface hardening.

Another factor in the selection of prior structure, either quenched and tempered or isothermally transformed, is the ease of processing in an individual plant. Structures from either program respond suitably if heat treated to the same

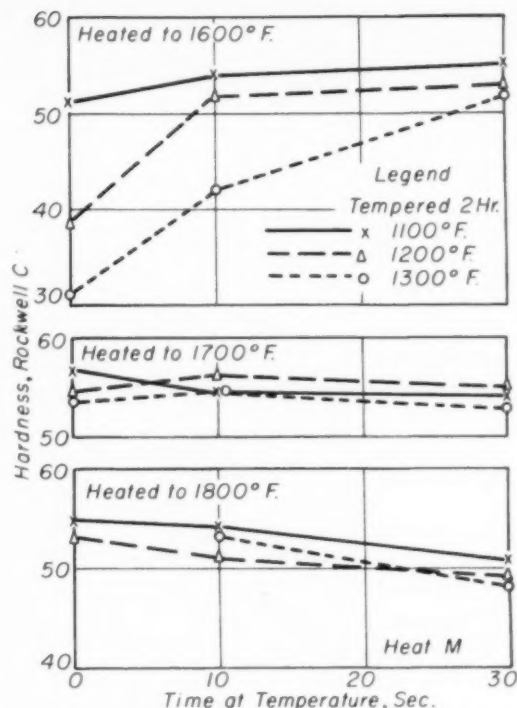


Fig. 4—Hardness of Samples of Ductile Iron (Heat M) Inductively Heated to 1600, 1700 or 1800° F. for Times Indicated and Then Water Quenched. Prior structures of wide variety (Fig. 2) will satisfactorily harden when heated to 1700° F.

mechanical properties. Since castings frequently have a large amount of combined carbon as cast, they may generally be successfully induction hardened from 1700° F. without preliminary heat treatment if the core properties are suitable. This temperature appears generally most suitable to minimize the influence of prior structure and to avoid retention of austenite. Where minimum case depths are required, a lower hardening temperature and a microstructure containing a minimum of massive ferrite are desirable.

Influence of Composition

Several heats of ductile iron varying principally in manganese and silicon were studied to determine the influence of composition on induction surface hardening (see Table I).

Perhaps the most prominent influence of composition is upon microstructure and mechanical properties before induction heating. The significant influence of silicon in raising the curves representing beginning and ending of isothermal transformation and decreasing the time required

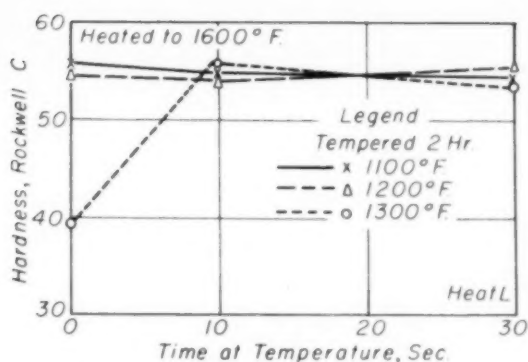


Fig. 5—Hardness of Sample of Low-Silicon Heat L, Quenched and Tempered, Then Inductively Heated to 1600° F. and Water Quenched. Compare with top diagram of Fig. 4 for effect of silicon

for complete ferritization is illustrated by comparing Heat N with 2.98% Si and Heat K with 1.87% Si as shown in Fig. 1. (In quenched structures silicon promotes more rapid ferritization on tempering.)

An increase in manganese (to 0.78%) appears to extend the time required for the beginning and ending of austenite transformation and for complete ferritization, particularly at temperatures below 1200° F. Thus for equivalent heat treating procedures one might expect greater amounts of combined carbon with high-manganese heats. However, essentially equivalent structures may be attained in all the heats studied, provided adjustments are made in the heat treatments.

The mechanical properties are likewise influenced by composition, partly as a direct alloying influence and partly as an indirect influence upon prior structure. In general, silicon appears to provide a better balance of mechanical properties—that is, the silicon steels have higher strength for similar ductility.

Response to Induction Heating—Silicon appears to decrease somewhat response to induction hardening in both isothermally transformed and in quenched and tempered prior structures. This appears to be a direct effect (perhaps an influence upon carbon diffusion) and an indirect effect (less combined carbon in the prior structure for a uniform heat treatment). The influence of silicon can be inferred by comparing the top diagram of Fig. 4 (Heat M; 3.10% Si, 0.78% Mn) and Fig. 5 (Heat L; 2.06% Si, 0.73% Mn).

Since the variation in prior structure produced by silicon can be largely overcome by a change

in heat treatment, and since higher induction hardening temperatures minimize the influence of prior structure, the slower response of high-silicon ductile irons to induction heating is not a major disadvantage.

Manganese appears to increase the tendency for retained austenite in the hardened structure, though this may also occur in low-manganese heats. Since manganese tends to stabilize austenite, this may be expected. Thus high-manganese heats may be more sensitive to excessive induction hardening temperatures.

Selection of Composition—The most outstanding observation concerning the influence of composition, within the limits studied, appears to be the relative insensitivity of successful induction heating response to composition. Variations in composition can be accommodated either by moderate changes in preliminary heat treatment or by using higher induction hardening temperatures.

However, since silicon provides a somewhat better balance of core properties and decreases the time required for partial ferritization, it appears that castings within the range of 3.25 to 3.50% total carbon, 2.5 to 2.75 silicon, 0.35 to 0.50 manganese, 0.65 to 0.85 nickel, 0.030 to 0.035 phosphorus and 0.01% sulphur would be preferred. Such analyses also respond excellently to induction surface hardening. Where castings have been made without consideration for surface hardening, modifications in initial heat treatment to control prior structure and selection of correct hardening temperature will result in successful surface hardening.

Control of Case Depth

The preceding discussion provides little data concerning either the properties of the hardened case or the case depths to be expected.

Case depth depends not only upon the metallurgical variables such as prior structure, composition, and hardening temperature, but also upon the characteristics of the heating apparatus, as well as the magnetic, thermal, and electrical characteristics of the ductile iron. The power available in the high-frequency converter and the frequency may both have an important influence. Thus, minimum case depths are produced with converters which operate at high frequency and have sufficient power available to bring the surface to the hardening temperature in a minimum of time so as to minimize conduction of heat to the interior. This, in turn, will depend upon the design of the induction heating

coil, the quenching fixture and the possible use of progressive localized hardening.

Furthermore, since the effective current penetration is directly proportional to the square root of the electrical resistivity of the iron and inversely proportional to the square root of its magnetic permeability, it is apparent that composition may influence the case depth. Increased silicon content, for example, appears to increase the case depths somewhat.

There is no limitation on maximum case depth—except perhaps the hardenability (in very large sections). However, there is a definite minimum, both as a result of the induction heating equipment and the electrical and metallurgical characteristics of the iron. While the minimum practical case depth in induction hardened steels is approximately 0.020 in., it may be considerably deeper in a ductile iron of appreciable ductility. The deeper case results from the higher hardening temperature required to put sufficient carbon in solution prior to quenching. Where minimum core ductility is required, the practical minimum case depth may approach that for steel.

Case Characteristics—Figure 6 illustrates depth-hardness curves obtained on 0.875-in. rounds with various quenched-and-tempered

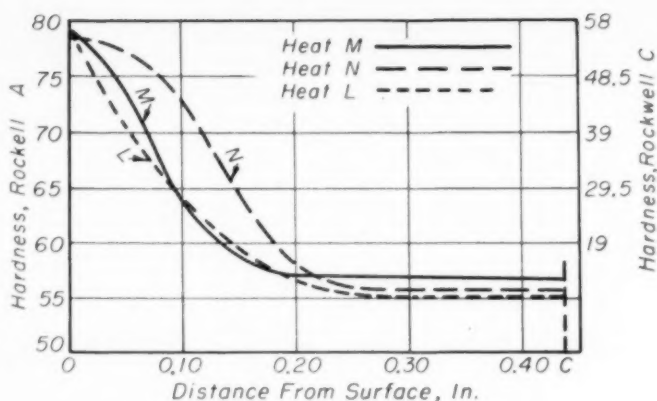


Fig. 7—Depth-Hardness Curves as They Are Affected by Composition. (See Table I.) Conditions same as in Fig. 6 except all samples were tempered 2 hr. at 1200° F. prior to surface hardening

prior structures; Fig. 7 various compositions. These rounds were case hardened using a 30-kw. spark-gap converter operating at a frequency of 300,000 cycles per sec. All were heated to a surface temperature of 1700° F. in a rotating fixture and immediately spray quenched in water.

In all instances the surface hardness measured Rockwell A-78 to 80, equivalent to C-54 to 58.

Although the prior microstructure has little influence on the surface hardness, it does upon the hardness gradient (Fig. 6). There appears to be a greater depth of high hardness and a steeper hardness gradient between the core and case as the combined carbon in the structure decreases. The "case depth", represented as the distance to a hardness of A-70, also increases somewhat as the prior tempering temperature increases. We believe that these variations are associated with significant variations in the electrical, thermal and, perhaps, magnetic characteristics of the ductile iron as its structure changes. It is also believed that the distribution of silicon in the structure may be a primary influence.

The depth-hardness curves of Fig. 6 are for a heat of ductile iron (Heat N) of recommended composition and hardening temperature. Its mechanical properties are given in Table II. These properties are to be expected in the core of the case hardened sections.

Composition (within the limits

Fig. 6—Effect of Prior Structure on Depth-Hardness Curves for Case Hardened Rounds, 0.875 in. Diameter, of Heat N. No dwell of current—that is, surface was spray quenched immediately upon reaching 1700° F. Prior treatment: oil quenched from 1650° F., tempered for 2 hr. as indicated

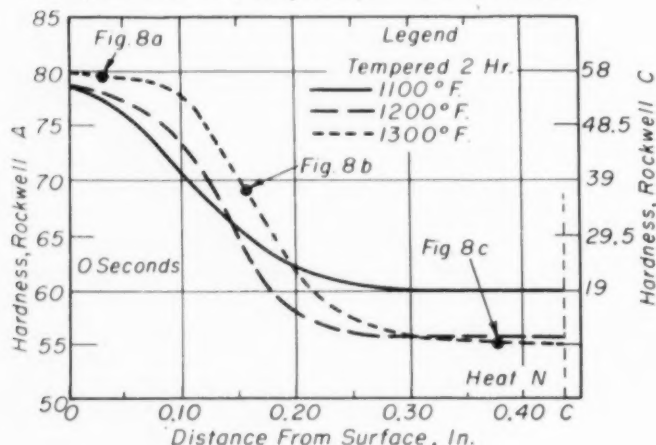


Table II — Mechanical Properties of Samples of Fig. 6 and 7
(All pieces oil quenched from 1650° F., tempered 2 hr. as noted)

HEAT	TEMPERING TEMPERATURE	TENSILE STRENGTH	YIELD STRENGTH	ELONGATION (a)	REDUCTION OF AREA	IMPACT RESISTANCE (b)
Influence of Prior Structure (Fig. 6)						
N	1100° F.	130,000	103,000	7%	5%	26
N	1200	89,000	68,000	12	13	58
N	1300	81,000	64,000	16	18.5	62
Influence of Composition (Fig. 7)						
N	1200	89,000	68,000	12	13	58
M	1200	87,000	67,500	10	10	40
L	1200	99,000	87,000	7	7.5	35

(a) A.S.T.M. Standard 0.250-in. diameter, 1-in. gage length tensile bars.

(b) Unnotched Charpy bars, broken at room temperature.

studied) appears to have a minor influence, although Heat N with low manganese maintains a higher hardness to a deeper level. (See Fig. 7.)

The microstructure of a surface hardened section is shown in Fig. 8. Uniform martensite with graphite spheroids exists for some depth from the surface, after which a mixture of martensite, ferrite and graphite spheroids with ever-increasing amounts of ferrite gradually merges into the core structure.

Summary

Ductile iron can be surface hardened by induction heating to provide a unique combination of properties. High case hardness is possible with

a wide variation of core properties. The operation does not appear to require unduly precise control, and while prior structure and composition have an influence, the hardening temperature can be adjusted for successful surface hardening in all structures except those that are substantially ferritized.

Optimum surface hardening may be expected with material containing 3.25 to 3.5 total carbon, 2.5 to 2.75 silicon, 0.35 to

0.50 manganese, 0.65 to 0.85 nickel, 0.03 to 0.035 phosphorus and 0.01% sulphur, surface hardened at 1700° F. However, the composition does not need to be closely adjusted. Prior microstructures containing a maximum amount of combined carbon, widely distributed, will produce minimum case depths, while microstructures containing large amounts of ferrite are responsible for deeper cases.


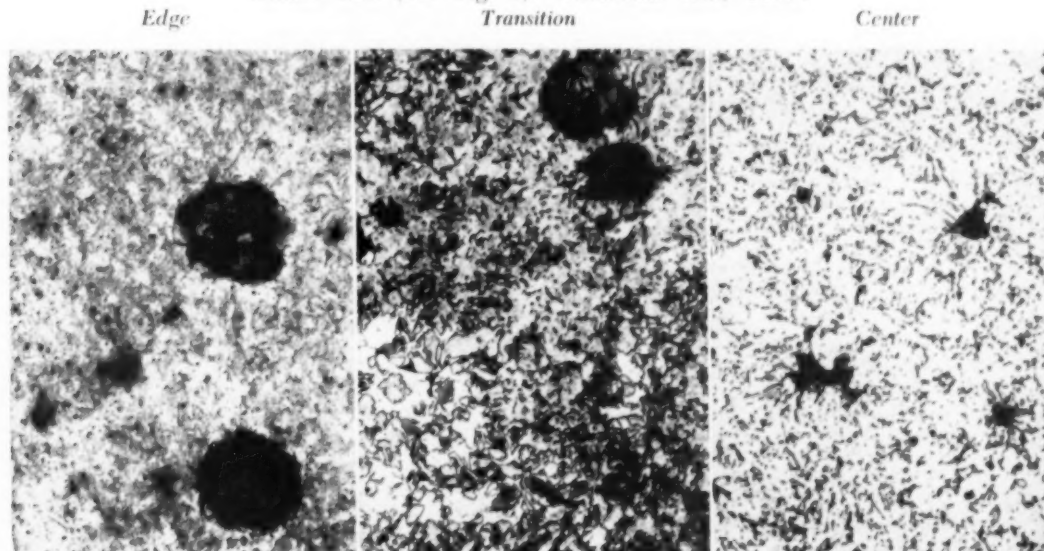
While tests on production pieces are required to determine the ultimate usefulness of surface hardened ductile iron parts, it is believed that the unique combination of properties provided offers many possibilities in the design of cast parts for engineering applications. 

Fig. 8—Typical Microstructures of Surface Hardened Ductile Iron (See Fig. 6). Picral-nital etch; 250×



Sigma Phase—a Review

By ADOLPH J. LENA*

Sigma can be identified by microscopic methods and by X-ray analysis of the bulk material or the concentrated phase. Sigma occurs in many binary and ternary systems, some of which compose the high-temperature alloys.

THE TWO preceding articles in this three-part series described the compositional limits and effects of sigma formation on stainless steels; this final part is devoted to the identification of sigma in stainless steels, as well as to some of the theoretical aspects of its formation in other binary and ternary alloys and its crystal structure.

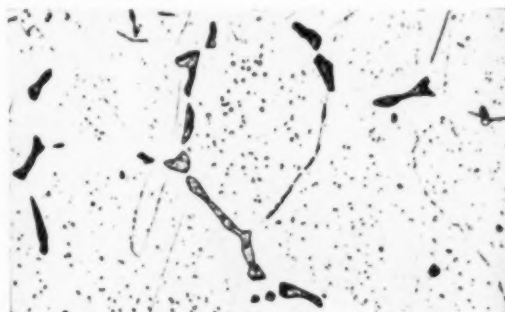
The microscopic identification of phases in stainless steels which contain sigma is often very difficult, particularly if the sigma particles are small, because of the similarity in etching characteristics of sigma and carbide. The presence of both constituents in the microstructure is a general condition in sigma-containing steels since carbides form more rapidly than sigma in the same temperature range. Further complications arise in some austenitic steels when small amounts of ferrite are present.

Etchants commonly used for stainless steels have been classified into three broad groups: (a) acid reagents of the immersion type, (b) electrolytic etchants, (c) alkaline ferricyanide reagents. The acid types (picric and hydrochloric acid in alcohol is common) usually attack austenite and leave carbides, sigma and ferrite in relief without differentiating among them. The electrolytic etchants, in general, attack sigma and carbides vigorously but the austenite relatively slowly so that it is possible to identify the ferrite phase by difference. In some steels, certain electrolytic etchants attack either carbide or sigma

more rapidly and it is often possible to distinguish between the two in this manner. A detailed study of the common etchants and their effects on these phases has been made by E. J. Dulis and G. V. Smith ("Symposium on the Nature, Occurrence and Effects of Sigma Phase", A.S.T.M., 1950), who found that no one etchant would provide a general differentiation of phases in all types of stainless steels.

The alkaline ferricyanide etchants have been used quite widely for identification of phases in steels where sigma is present. These are the Murakami and modified Murakami solutions and may be used either cold or boiling. They are staining etchants and as such are, in general, unsatisfactory. If used hot, the carbides are usually stained a dark brown, sigma assumes a series of opalescent colors, ferrite turns a light tan and the austenite remains unaffected. Such solutions work well on ferritic alloys, but not on austenitic alloys, because on the latter the colors of staining are not consistent. However, the staining solutions are useful for austenitic steels when employed in conjunction with other etchants. An

Fig. 1—Type 310 Etched in Aqua Regia With Sigma Attacked and Carbides in Relief. Steel was annealed before aging. 1000×



*Associate Director of Research, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

EDITOR'S NOTE—This paper is a review of the most significant investigations made to date of the formation of sigma and of its effect on the properties of alloys. (See *Metal Progress* for July and August for the first and second parts of this article.) To preserve its continuity, many of the credits and the complete bibliography submitted with the paper have been deleted.

example of this technique is the etching sequence recommended by Dulis and Smith:

1. Picric and hydrochloric acids in alcohol to reveal all constituents.

2. Alkaline ferricyanide at room temperature to stain carbides and leave sigma and ferrite unattacked.

3. Chromic acid electrolytically to severely attack carbides and sigma, thus differentiating either from ferrite.

Since the effect of most etchants varies so widely with composition, it appears unlikely that any single reagent will give positive identification of carbides and sigma in all types of stainless steels. There are a number of etchants which have a selective effect on carbides or sigma in a particular type of steel and can be applied with reliability when the type of steel being examined is known. Etchants of this kind are listed in Table 1, and examples of some of their effects are shown in Fig. 1 to 4. It will be noted that the electrolytic chromic acid which attacks sigma in Type 310 and leaves carbide in relief has the opposite effect on the chromium-manganese austenitic stainless steel. In molybdenum-bearing 18-8 steels (Types 316 and 317), the carbides are attacked faster than sigma when etched electrolytically in sodium cyanide. Overetching must be avoided in order to differentiate between the carbides and sigma, and this can be done by etching for shorter time than is normal to show carbides in stainless steels, or by reducing the strength of solution from 10 to 5%. Further aids to the identification of phases are a knowledge of previous heat treatment and the use of a magnetic test for positive differentiation between ferrite and sigma.

Table 1—Etching Reagents for Differentiating Sigma From Carbides

TYPE	ETCHANT	ETCHING EFFECTS	
		CARBIDES	SIGMA
310, 314, 321	Aqua regia	In relief	Attacked and recessed
310, 314, 321	Cupric sulphate	In relief	Attacked and recessed
310, 314, 321, 347	Ferric chloride and hydrochloric acid in water	In relief	Attacked and recessed
316, 317	Electrolytic sodium cyanide	Attacked	In relief
310	Electrolytic chromic acid	In relief	Attacked
15% Cr, 17% Mn	Electrolytic chromic acid	Attacked	In relief

Another etching sequence recommended by J. J. Gilman (*Transactions* \oplus , Vol. 44, 1952, p. 556) takes advantage of the fact that strong hydroxide solutions used electrolytically color the sigma phase more rapidly than the carbides if the solutions are concentrated, and have the opposite effect if they are dilute:

1. Picric acid and hydrochloric acid (Vilella's etch) to outline the general structure.

2. Electrolytic 10N potassium hydroxide just long enough to color the sigma only and not the carbides.

3. Electrolytic concentrated ammonium hydroxide to color the carbides.

This technique has been applied to the identification of phases in Types 302, 316, 321, 310 and 314 and a cast steel containing 0.40% C, 1.10% Si, 6.4% Ni and 24.0% Cr. The same method has been used in our laboratory on Type 310 with results far superior to those of any other etching tech-

Fig. 2—Type 310 Etched in Electrolytic 10% Chromic Acid; Sigma Attacked and Carbides in Relief. Steel was cold rolled before aging. 1000 \times

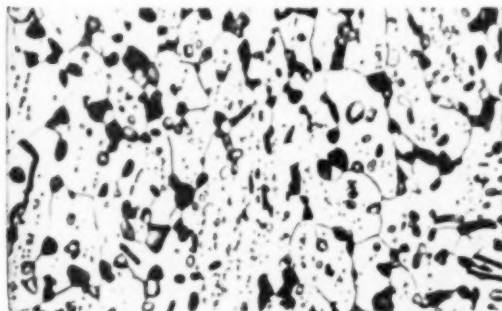


Fig. 3—Electrolytic Etching of Austenitic Cr-Mn Steel in 10% Chromic Acid Attacks Carbides and Leaves Sigma in Relief. 1000 \times



nique for distinguishing between sigma and carbides. Close control of the voltage and time is required to avoid overetching.

Heat tinting appears to have some merit for the identification of sigma, but this method has not been fully exploited. Heat tinting has been found to cause austenite to turn blue-green and the sigma orange while carbides remain white. However, this method does not differentiate between ferrite and sigma since both have the same orange color. An electrolytic chromic acid etch followed by staining in an alkaline permanganate solution has been recommended for the identification of sigma in chromium-base Fe-Cr-Mo alloys. Other special techniques for specific alloys are mentioned in many of papers that have been written on this subject.

Positive identification of sigma can be made by X-ray analysis from its characteristic diffraction pattern which is greatly different from that of any other phase found in stainless steels. The actual line spacings vary somewhat with composition; in the ternary iron-chromium-molybdenum system, where the sigma region extends to at least 40% molybdenum, both a and c vary linearly with molybdenum content, and the $c:a$ ratio is constant.

If the sigma is present in amounts too small to be detected by X-ray analysis of bulk specimens, suitable means must be taken to concentrate the sigma. The method devised by W. J. Barnett and A. R. Troiano (*Metal Progress*, Vol. 53, March 1948, p. 366) is to electrolytically etch in a 10% ferric chloride solution to concentrate the sigma on the surface by selective dissolution of the matrix. Etching can be prolonged to dissolve the

entire specimen. The extraction is made in a cell such as shown in Fig. 5. The residues obtained from this extraction are filtered, washed, dried and analyzed by X-ray methods. Very small amounts of sigma can be detected with this method. Other techniques reported for the concentration of sigma include the chemical attack of the matrix by a hydrochloric acid-picric acid solution to concentrate sigma in ferritic alloys described by R. M. Fisher, E. J. Dulis and K. G. Carroll (*Transactions, American Institute of Mining and Metallurgical Engineers*, Vol. 197, 1953) while T. P. Hoar and K. W. J. Bowen (*Transactions*, Vol. 45, 1953) have provided quantitative data on the chemical composition of sigma and the austenite in equilibrium with it in an 18-8-3-1 Cr-Ni-Mo-Ti steel by selectively dissolving these constituents by electrolysis in hydrochloric acid and sulphuric acid solutions.

Sigma in Other Binary and Ternary Alloys

Considerable interest has arisen in recent years in the discovery of phases with the sigma structure in binary and ternary alloys of transition metals other than iron-chromium and iron-chromium-nickel. The binary and ternary systems in which sigma has been discovered are listed in Table II. Sigma phase structures of the binary alloys that contain a heavy element (either tungsten or molybdenum) are stable only at high temperatures and decompose on cooling. All of the other sigma structures are found in binary systems of the first long period and are stable at low temperatures.

The composition ranges of sigma phase structures have been determined for a limited number

Fig. 4—Type 316 Etched Electrolytically in Sodium Cyanide: (Left) Carbides Attacked and Sigma Stained and in Relief; (Right) Sigma Stained and in Relief; No Carbides in This Steel. Both at 1000 \times

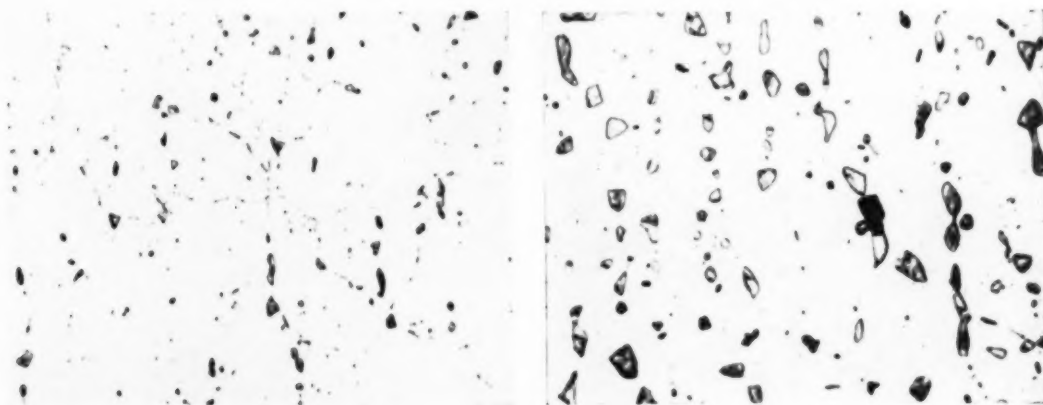


Table II — Sigma-Containing Alloys

BINARY SYSTEMS	REFERENCE*
Iron-Chromium	1
Cobalt-Chromium	2, 3, 4
Iron-Vanadium	5
Nickel-Vanadium	6, 7
Chromium-Manganese	6, 8, 9
Vanadium-Manganese	6
Vanadium-Cobalt	6, 7
Iron-Molybdenum	10
Molybdenum-Manganese	11, 12
Cobalt-Molybdenum	13
Cobalt-Tungsten	13
Iron-Tungsten	13
TERNARY SYSTEMS	
Iron-Chromium-Molybdenum	14, 15, 16
Chromium-Cobalt-Iron	4, 17
Chromium-Cobalt-Nickel	4, 17
Iron-Chromium-Molybdenum	18
Iron-Chromium-Tungsten	18
Chromium-Cobalt-Molybdenum	17
Chromium-Nickel-Molybdenum	17
Iron-Chromium-Vanadium	19
Iron-Chromium-Cobalt-Nickel	20

*See references on p. 126.

of ternary systems. A description of the phase boundaries in iron-chromium-nickel and iron-chromium-manganese alloys was given in Part I of this article (*Metal Progress* for July, p. 86); other ternary systems which have been investigated are listed in Table II. These systems form the basis of some of the high-temperature alloys; the formation of sigma in such alloys may have a serious embrittling effect.

Theories of Sigma Phase Formation — A number of theories have been proposed to account for the formation of sigma phase structures in binary alloys of the transition metals.

When sigma phase was known only in the iron-chromium and iron-vanadium systems, it was postulated that sigma was a superlattice of the AB type, but subsequent discoveries of this phase in other systems where the range of homogeneity did not include the equiatomic composition eliminated this possibility. The discovery of sigma in the iron-molybdenum system refuted the belief that the atomic number of the elements in a binary system must bracket manganese in order for sigma phase to be found in that system.

The theory of sigma phase for-

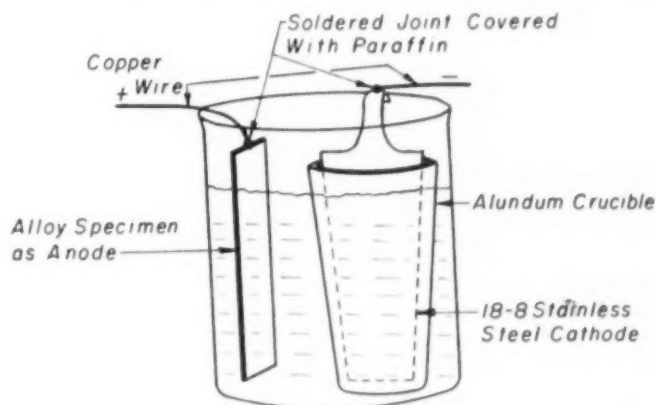
mation in alloys of elements of the first long period has been described by E. H. Sully in the *Journal of the Institute of Metals*, Vol. 80, December 1951. The existence of isomorphous phases of a characteristic structure in different alloy systems at compositions which differ from one system to another has been satisfactorily explained by Hume-Rothery and his co-workers on the basis that the phase appears at a critical ratio of valency electrons to atoms. The most familiar of these are the beta-brass structure with an electron-to-atom ratio of 3:2, the gamma-brass structure with a ratio of 21:13 and the close-packed hexagonal structure with a ratio of 7:4. Such phases have come to be known as electron compounds. Sully has found good agreement between actual sigma phase limits of several systems and those calculated on the basis of an electron:atom ratio of 1.7. The results of similar studies made by other investigators confirm this value for binary alloys, as well as for the several ternary alloys investigated.

It has been suggested that the formation of sigma depends on the following two conditions:

1. The atomic diameters of the two alloying elements do not differ by more than 8%. (An exception to this is the Fe-Mo alloys where the difference is 10% but the structure is unstable below 2155° F.).
2. One of the two metals has a body-centered cubic structure while the other is face-centered cubic in at least one of its allotropic forms.

Chi Phase — Of recent interest is the discovery of the chi phase in iron-chromium-nickel-molybdenum alloys. This new phase has a body-

Fig. 5 — Electrolytic Extraction Cell for the Concentration of Minor Phases in Stainless Steels. Electrolyte is 350 g. ferric chloride in 1000 ml. water at room temperature in a 3-l Pyrex beaker; current density 0.125 amp. per sq.ft.; Crucible is Norton 9421 (P. K. Koh)



centered cubic structure of spacing $A_0 = 8.860$ kX which is sufficiently different from the sigma phase (with which it may coexist at the same temperature) that they may be easily distinguished. The chi phase has so far been found only in steels containing molybdenum and may be associated with the presence of that element. The possibility of chi being an intermediate stage in the formation of sigma is suggested by the work of P. K. Koh (*Transactions of the American Institute of Mining and Metallurgical Engineers*, Vol. 197, 1953, p. 339) who found only chi in Type 316 which had been annealed before aging, and only sigma in the same steel which had been cold worked prior to aging. Koh found chi in Type 316, ELC316, and 317, as well as in 23 Cr, 10 Mo and 27 Cr, 1.6 Mo alloys.

The Crystal Structure of Sigma

The true tetragonal symmetry of sigma was first established slightly more than three years ago by L. Menezes, J. K. Roros and L. A. Read ("Symposium on the Nature, Occurrence and Effects of Sigma Phase", A.S.T.M., 1950) who were able to isolate single crystals of sigma by careful fragmentation of brittle ferrite grains which initially were 1/16 in. in diameter. Prior to this work, it was believed that sigma was either triclinic or monoclinic because attempts to index the Debye lines from the sigma phase on the basis of a hexagonal, tetragonal or orthorhombic cell were unsuccessful. The tetragonal symmetry of sigma was confirmed by another team of researchers who determined the correct lattice parameters of sigma in the Fe-Cr system. A primitive tetragonal cell containing 30 atoms with $a = 8.799\text{\AA}^*$ and $c = 4.546\text{\AA}$ was discovered. Uniformly strong reflections coming from a number of high index planes suggested the positioning of 15 atoms at the point of a slightly distorted hexagonal net.

At about the same time, C. W. Tucker (*Science*, Vol. 112, Oct. 20, 1950, p. 448) described the beta-uranium structure as having an over-all tetragonal symmetry but pseudo-hexagonal along the c axis. On the basis of density measurements and the size of the unit cell (which was approximately the same as that determined for sigma), it was decided that the beta-uranium cell contained 30 atoms. Subsequent work by other investigators revealed that the sigma phase structure is the same as the beta-uranium structure as derived by Tucker and it was possible to index all the FeCr sigma phase lines on the basis of a

30-atom tetragonal cell with $a = 8.79\text{kX}$ and $c = 4.55\text{kX}$. The only disagreement is in regard to the exact space grouping of the atoms; Tucker has chosen a $P4/mnm$ group which implies a "puckering" of the hexagonal layers in uranium, whereas the $P4/nm$ group proposed for sigma by J. S. Kasper and his co-workers necessitated that the hexagonal layers be flat.

Summary—Identification of sigma by microscopic methods can be fairly certain provided that a suitable etching procedure for a particular type of steel is chosen and that the size of the sigma particles is sufficiently large to be resolved. Difficulty is encountered when the particle size of the sigma and carbides is very small; then X-ray diffraction is often the only positive method of establishing its presence. However, because the amount of sigma and carbides present is often too small to be detected by conventional X-ray analysis of bulk material, the phases must be concentrated. Methods which have been used successfully include dissolution of the matrix by electrolysis in 10% ferric chloride solution or by immersion in a hydrochloric-picric acid solution after which the residues are cleaned and analyzed by X-ray.

Sigma phase structures have been observed in a large number of binary systems and it has been suggested that sigma is an electron compound with an electron-to-atom ratio of 1.7. The structure of sigma has been found to be identical with beta-uranium in that it possesses tetragonal symmetry but is pseudo-hexagonal along the c axis. The unit cell contains 30 atoms with lattice parameters of $a = 8.79\text{kX}$ and $c = 4.55\text{kX}$. ☼

References

(See Table II on p. 125)

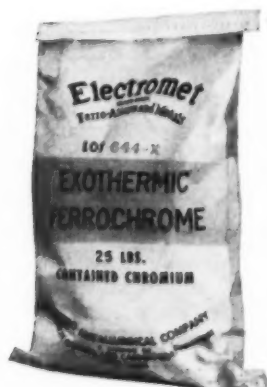
1. "Brittle Constituent of Iron-Chromium System — (Sigma Phase)", by A. J. Cook and F. W. Jones, *Journal of the Iron and Steel Institute*, Vol. 148, August 1943, p. 217.
2. "An Electron Compound in Alloys of the Transition Metals", by A. H. Sully and T. J. Heal, *Research*, Vol. 1, March 1948, p. 288.
3. "The Cobalt-Chromium Binary System", by A. R. Elsea, A. B. Westerman and G. K. Manning, *Metals Technology*, Vol. 15, June 1948.
4. "The Sigma Phase in Ternary Cr-Co-Fe and Cr-Co-Ni Alloys", by P. A. Beck and W. D. Manly, *Transactions, American Institute of Mining and Metallurgical Engineers*, Vol. 185, June 1949, p. 354.

(Continued on p. 128)

*A stands for Angstrom unit.



**HERE'S WHY
YOU SHOULD
SPECIFY
ELECTROMET
TRADE-MARK
EXOTHERMIC
FERROCHROME**



Use ELECTROMET exothermic ferrochrome when making ladle additions of chromium to steel, and secure the following advantages:

FAST SOLUBILITY

ELECTROMET exothermic ferrochrome has a high rate of solubility. Its exothermic power prevents chilling.

HIGH CHROME RECOVERY

About 92% of the chromium is recovered regularly. This provides close control of chromium specifications in the finished steel.

LOW CARBON PICKUP

Because of the high chromium-to-carbon ratio, only 0.08% carbon is introduced when adding 1% chromium.

HIGH IGNITION TEMPERATURE

ELECTROMET exothermic ferrochrome has an ignition temperature in excess of 750 deg. F. This means maximum protection against fire hazard while in storage.

EASY TO HANDLE

The alloy comes packed either in steel cans, or in strong, flame-proof and moisture-proof bags. Each holds about 44 lb. of material containing exactly 25 lb. of chromium.

NO CHARGE FOR PALLETS

At customer option, cans or bags will be shipped on pallets, *at no extra charge*. Each pallet holds 60 cans or 80 bags.

QUICK DELIVERY

Write, wire or phone the nearest office of Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, for immediate delivery of ELECTROMET exothermic ferrochrome. Offices in Birmingham, Chicago, Cleveland, Detroit, Houston, Los Angeles, New York, Pittsburgh, and San Francisco. Ask also about ELECTROMET exothermic silicon-chrome for the production of low-alloy steels.

"Electromet" is a registered trade-mark of Union Carbide and Carbon Corporation.

Sigma Phase . . .

(Continued from p. 126)

5. "On the System Iron-Vanadium", by F. Wever and W. J. Jellinghaus, *Mitteilungen aus dem Kaiser-Wilhelm-Institut für Eisenforschung*, Vol. 12, 1930, p. 317.

6. "New Sigma Phases in Binary Alloys of the Transition Elements of the First Long Period", by W. B. Pearson, J. W. Christian and W.

Hume-Rothery, *Nature*, Vol. 167, Jan. 20, 1951, p. 110.

7. "Crystallography of the Sigma Phase", by P. Pietrokowsky and Pol Duwez, *Transactions, American Institute of Mining and Metallurgical Engineers*, Vol. 188, 1950, p. 285.

8. "The Equilibrium Diagram of the System Chromium-Manganese", by S. J. Carlile, J. W. Christian and W. Hume-Rothery, *Journal of the Institute of Metals*, Vol. 76, Oct. 1949, p. 169.

9. "The Constitution of Chromium-Manganese Alloys Below 1000° C.", by W. B. Pearson and W. Hume-Rothery, *Journal of the Institute of Metals*, Vol. 81, Feb. 1953, p. 311.

10. "A Molybdenum Sigma Phase", by H. J. Goldschmidt, *Research*, Vol. 21, July 1949, p. 243.

11. "The Crystal Structure of the Sigma Phase in the Co-Cr System", by J. S. Kaspar, B. F. Decker and J. R. Belanger, *Journal of Applied Physics*, Vol. 22, March 1951, p. 361.

12. "Formation of Sigma Phase in the Mn-Mo System", by B. F. Decker, R. M. Waterstrat and J. S. Kaspar, *Journal of Metals*, Vol. 5, Nov. 1953, p. 1476.

13. "A Further High Temperature σ -Phase and a Note on σ - ξ Relations", by H. J. Goldschmidt, *Research*, Vol. 4, July 1951, p. 343.

14. "The Ternary System Chromium-Molybdenum-Iron", by J. W. Putnam, R. D. Potter, and N. J. Grant, *Transactions, American Society for Metals*, Vol. 43, 1951, p. 824.

15. "Constitution of Iron-Chromium-Molybdenum Alloys at 1200° F.", by S. R. Baen and Pol Duwez, *Transactions, American Institute of Mining and Metallurgical Engineers*, Vol. 191, 1951, p. 331.

16. "Chromium-Base Alloys", by W. L. Havekotte, C. T. Greenidge and H. C. Cross, *Proceedings, American Society for Testing Materials*, Vol. 50, 1950, p. 1101.

17. "Intermediate Phases in Ternary Alloy Systems of Transition Elements", by S. Rideout, W. D. Manly, E. L. Kamen, B. S. Lement, and P. A. Beck, *Transactions, American Institute of Mining and Metallurgical Engineers*, Vol. 192, 1951, p. 872.

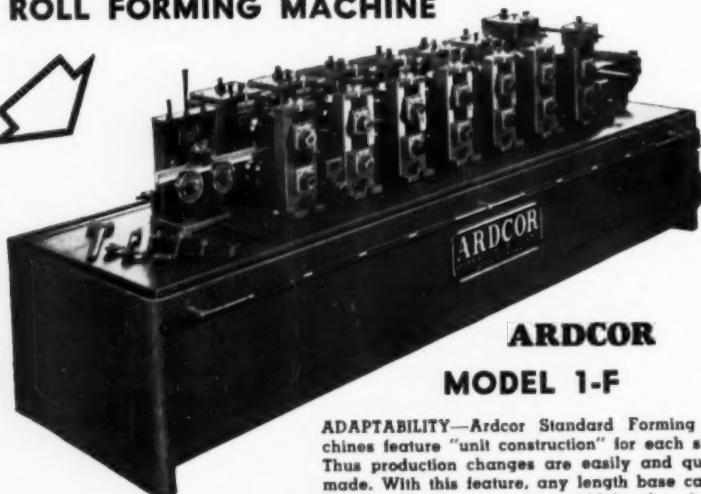
18. Phase Diagrams of the Ternary Systems Fe-Cr-W and Fe-Cr-Mo at Low Temperatures, by H. J. Goldschmidt, *Symposium on High Temperature Steels and Alloys for Gas Turbines*, Iron and Steel Institute, July 1952, p. 249.

19. "Phase Relationships in the Iron-Chromium-Vanadium System", by H. Martens and Pol Duwez, *Transactions, American Society for Metals*, Vol. 44, 1952, p. 484.

20. "A Rationalization of Measured High Temperature Properties of Fe-Cr-Co-Ni Alloys", by J. D. Nisbet, and W. K. Hibbard, Jr., *Journal of Metals*, Vol. 5, April 1953, p. 1149.



The Production-WISE ROLL FORMING MACHINE



**ARDCOR
MODEL 1-F**

ADAPTABILITY—Ardcor Standard Forming Machines feature "unit construction" for each stand. Thus production changes are easily and quickly made. With this feature, any length base can be furnished to accommodate additional units as required.

Ardcor Roll Forming machines embody the precision, accuracy and stability found only in the highest grade machine tools. In addition, Ardcor offers a completely engineered installation—cradle reels, roll forming machines, roller dies, flying cut-off fixtures, etc.—from one qualified source.

Likely as not your special shapes can be ideally handled by a standard Ardcor machine. Your inquiry is invited—without obligation.

Spindle Diameter.....	1½"
Roll Diameter.....	4¼" to 7"
Horizontal Distance Between Spindles.....	12"
Roll Space on Standard Machine.....	10"
Capacity Max.....	.072

Machines Available in All Spindle Diameters.

American ROLLER DIE CORPORATION

29551

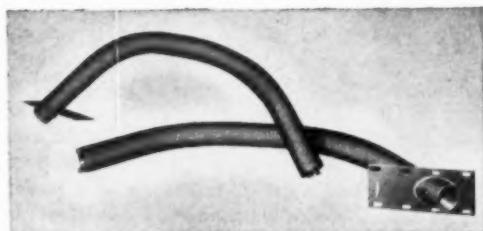
Clayton

Wickliffe, Ohio



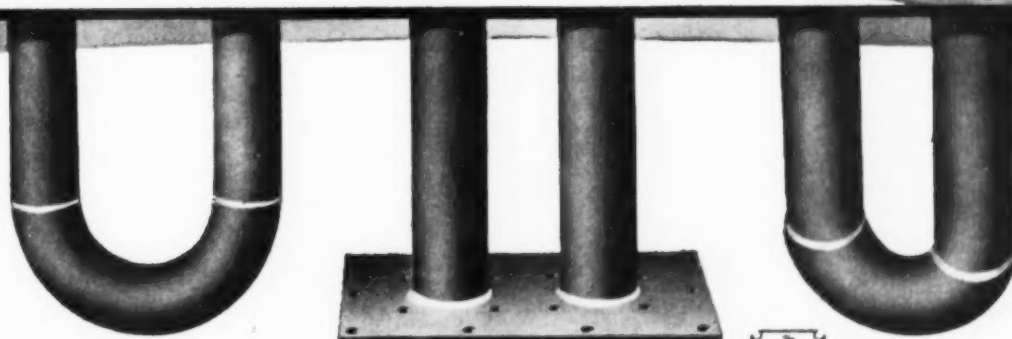
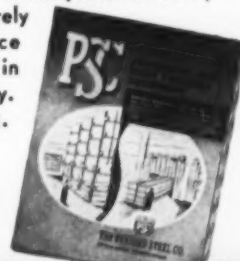
'PSC' RADIANT TUBES in *Any Design or Dimension*

The increasingly wide adoption of PSC "Thin-Wall" radiant tubes by furnace builders is based on three impressive advantages: (1) Their light-wall, sheet alloy-construction saves both furnace



time and fuel. Being 33 to 50% lighter than cast tubes, they cut initial cost and handling time. (2) Return bends are fabricated to give uniform wall thickness throughout, promoting uniform flow of gas. (3) Because their smooth dense walls minimize carbon build-up and consequent burn-out, PSC tubes are setting entirely new standards for service life. Precision-assembled in any size, shape or alloy. Write as to your needs.

Send for
HEAT-TREAT CATALOG



THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING Sheet Alloys

☆☆☆ OFFICES IN PRINCIPAL CITIES ☆☆☆

Personal Mention



George V. Luerssen

GEORGE V. LUERSSEN, vice-president in charge of metallurgy of the Carpenter Steel Co., Reading, Pa., has retired after 47 years of service with the company. Some of the contributions made under his guidance include the development of free-machining invar, refinements in the magnetic properties of 30% nickel alloys, and establishment of procedures for controlling the hardenability and grain structure of carbon steels. He is a co-inventor of the torsion impact testing machine and helped develop a new low-temperature air hardening die steel. Mr. Luerssen is co-author of the textbook "Tool Steel Simplified".

Luerssen is a past chairman of the Metals Handbook Committee, has been chairman of its subcommittee on steel melting since 1933, and chairman of the toolsteel subcommittee 1943-47. In 1945 he received the Bradley Stoughton Award of the Lehigh Valley Chapter. He was again honored in 1949 as the first person to receive the David M. McFarland Award of the Penn State Chapter for outstanding accomplishments in the field of metallurgical research. He is a graduate of Pennsylvania State University and a past chairman of the Lehigh Valley Chapter. He is also a member of A.I.M.E., A.S.T.M. and British Iron and Steel Institute.



Carl B. Post

CARL B. POST has been appointed head of the metallurgical and research departments of the Carpenter Steel Co., Reading, Pa. Dr. Post has been chief metallurgist of the company since July 1951, and a member of the metallurgical staff since 1938. He is widely known for his research contributions in the fields of automotive and aircraft valve steels, particularly the addition of nitrogen for better workability and high-temperature strength. Other developments made under his supervision are in the fields of stainless steels and air hardening tool and die steels. Among his most recent contributions is the use of rare-earth elements, such as cerium and lanthanum, to improve the hot workability of corrosion resistant and heat resistant alloys. Among the awards held by Dr. Post is the Bradley Stoughton Plaque presented to him last year by the Lehigh Valley Chapter. This award is made annually to the Lehigh Valley metallurgist who has accomplished the most outstanding and generally useful work in the field of metallurgy. Dr. Post is a graduate of West Virginia University, and also holds a Ph.D. degree in physical chemistry from Pennsylvania State University. In addition to he is a member of the Society of Automotive Engineers and the A.I.M.E.



Otto Zmeskal

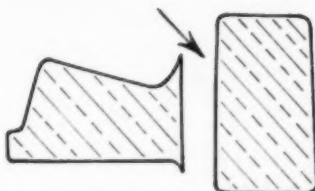
OTTO ZMESKAL has recently been appointed research professor, department of mechanical engineering, College of Engineering, University of Florida. Dr. Zmeskal graduated from Armour Institute of Technology in 1936 with a B.S. in Chemical Engineering. After a summer as practice apprentice in Carnegie-Illinois Steel Corp. blooming mill he returned to Armour as instructor in chemistry and metallurgy, earning his M.S. degree in Metallurgy in 1938. He then entered Massachusetts Institute of Technology, receiving his Sc.D. in Physical Metallurgy in 1941.

Dr. Zmeskal then returned to Armour (by then combined with Lewis Institute to form the Illinois Institute of Technology) as assistant professor of metallurgy. While there he set up the radiographic laboratory and wrote a book on "Radiographic Inspection of Metals", published by Harper Brothers. In 1943 he became associated with the Universal-Cyclops Steel Corp., and was made director of research of the Bridgeville Division in 1944. In 1946 he was called back to Illinois Institute of Technology to initiate and direct a new department of metallurgical engineering.

He is a past chairman of the Chicago Chapter, and in 1953 he was granted the Society's Teaching Award. In his work in Florida, Dr. Zmeskal will conduct research and graduate teaching in metallurgy and assist in the development of the metallurgical industry and mineral resources of the State of Florida.

(Continued on p. 132)

See How FORGINGS CAN SAVE MONEY



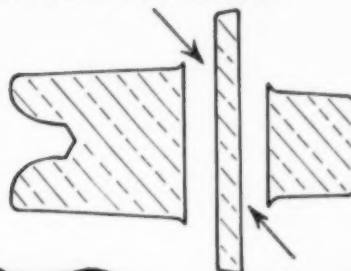
(Below) This forged brass part was originally made from a casting and a tube, silver soldered, as indicated in the drawing. Forgings can save a lot of money!



Photos of forgings shown are approximately 3 times larger than actual size.



(Above) Brass part as now forged in one piece. Drawing shows how it was originally made in three pieces, two made of tube and the other from sheet, silver soldered.



The two brass parts shown here were originally built up out of separate pieces, silver soldered together. That was the difficult and expensive way. Then the manufacturer and Revere worked together to see if forgings could not be used. Designs and dies were worked out, and for a number of years Revere has kept a steady flow of these parts going to the customer. He reports that the forgings not only save money, but are superior: stronger, more dense, with a better finish, and machining is faster and easier.

If you have sub-assemblies made of several parts, look into forgings. They may offer important economies. Revere makes forgings in copper and its alloys, and aluminum alloys. See the nearest Revere Sales Office.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N. Y.
Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.;
Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N. Y.
Sales Offices in Principal Cities... Distributors Everywhere.
SEE "MEET THE PRESS" ON NBC TELEVISION, SUNDAYS

Personals

Lucio Fausto Mondolfo has succeeded **OTTO ZMESKAL** as director of the department of metallurgical engineering at Illinois Institute of Technology. Dr. Mondolfo and Dr. Zmeskal have written a textbook on "Engineering Metallurgy" soon to be published.

Charles A. Dietz, Jr. has been appointed plant manager of Technical Metal Processing, Inc., Cleveland.

George J. Fischer has been appointed director of the metallurgical department of Sam Tour & Co., New York City. A metallurgist at the Western Electric Co. for two and a half years, Mr. Fischer has also been an instructor at the Polytechnic Institute of Brooklyn, from which he holds bachelor's and master's degrees in metallurgical engineering.

John G. Thomas is now employed at the Crucible Steel Co. of America, working out of its central toolsteel sales office in Syracuse.

John K. Gibson received his B.S. in process metallurgy from the University of California last January and is presently taking the Allis-Chalmers graduate training course.

Duane H. Fiesel has accepted a position with Dow Chemical Co., Midland, Mich., as a research and development engineer in the experimental foundry section of the manganese dept., after graduating from Michigan College of Mining & Technology last May.

Elliott Rennhack recently accepted a position with the New Jersey Zinc Co. in the research dept. where he works on design of laboratory equipment and development of new processes.

N. P. Norlie is now general sales manager of the Wilbur B. Driver Co., Newark, N. J., after having served this company as western manager in Chicago for 25 years.

Arden L. Bement, Jr. received his metallurgical engineering degree from the Colorado School of Mines in May and is now employed at the Hanford Atomic Products Operation of General Electric Co.

Archie L. Spratt is now employed at Vanadium-Alloys Steel Co., Latrobe, Pa., in the metallurgy laboratory. He graduated from Massachusetts Institute of Technology earlier this year.

Peter E. Kyle has resigned as professor of metallurgical engineering at Cornell University to join Lesells & Associates Inc., Boston, as vice-president. He will supervise research and development in the fields of mechanical engineering, electronics, and mathematical physics.

C. A. Blesch is now with Heat and Control, Inc., San Francisco, where he is associated with **J. C. Harris, Jr.** and **Clark K. Benson**, in industrial process heating for the metal industry and other fields.

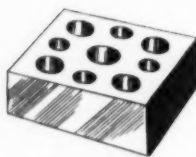
William C. Buell, Jr., who is widely known as an authority on steel refining and steel ingot practice, and for more than 20 years a member of the staff of Arthur G. McKee & Co. of Cleveland, has resumed private practice in Cleveland as consultant, specializing in matters concerned with steel ingot production.



Clean H.S.S. Hardening is a MUST at LUX CLOCK

At The Lux Clock Mfg. Co. of Waterbury, Conn., an average of 165 special intricate cutting tools, blanking dies and punches are heat treated daily. Quality, with freedom from scale or decarburization, is a "must" to avoid costly tool spoilage.

By using their Sentry Furnace and The Sentry Diamond Block Atmosphere, Lux say they are assured of consistent quality hardening on all their tools and dies made from high speed or air hardening steels.



A high-carbon, high-chrome blanking die—typical of items heat-treated at Lux.

Sentry

ELECTRIC FURNACES

THE SENTRY CO. • FOXBORO • MASS.



Request Catalog L-35

Tells the full story of Sentry Furnaces and The Sentry Diamond Block Method.

Product: Storage Tank
Material: $\frac{3}{4}$ " thick 2S Aluminum
Equipment: 150 kv X-Ray Machine

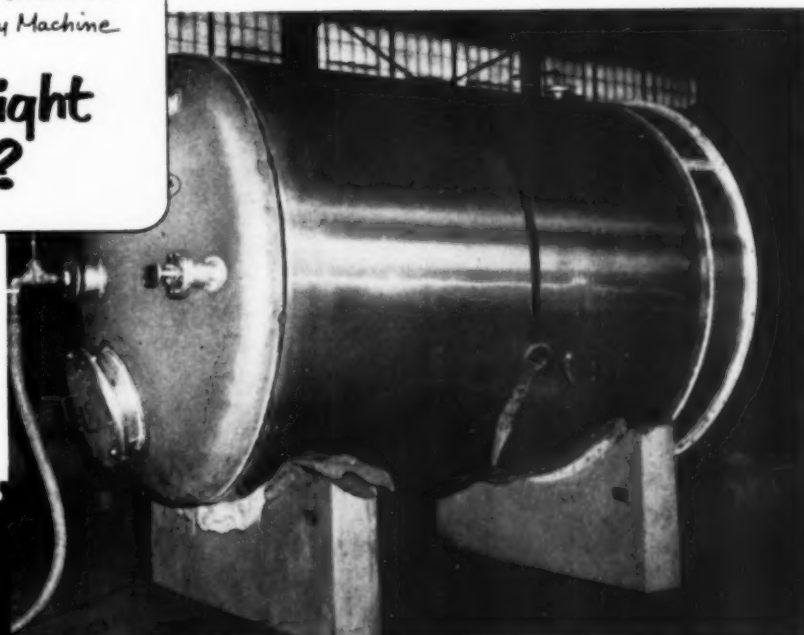
What's the right X-ray film?

KODAK INDUSTRIAL X-RAY FILM, TYPE A.

Specifications for this tank—designed to operate from vacuum to 25 pounds' pressure—called for welded 2S aluminum. To determine the most suitable welding method and to be sure of high-quality results, radiographs were called for.

To make these radiographs, the radiographer used Kodak Industrial X-ray Film, Type A; 100 kv, 7 secs. at 36" distance.

With light alloys, Type A has the speed to keep exposures reasonably short even at low voltages. Its high contrast and fine graininess also permit taking full advantage of high kv machines in working with thick dense materials.



THERE'S A RIGHT FILM FOR EVERY PROBLEM

Whatever your radiographic problem, you'll find the best means of solving it in one of Kodak's four types of industrial x-ray film. This choice provides the means to check castings and welds efficiently, offers optimum results with varying alloys, thicknesses and radiographic sources.

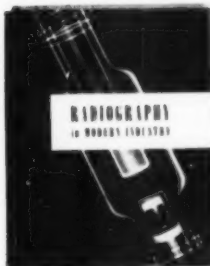
Type A—has high contrast and fine graininess with adequate speed for study of light alloys at low voltage and for examining heavy parts at intermediate and high voltages. Used direct or with lead-foil screens.

Type F—provides the highest available speed and contrast when exposed with calcium tungstate intensifying screens. Has wide latitude with either x-rays or gamma rays when exposed directly or with lead screens.

Type K—has medium contrast with high speed. Designed for gamma ray and x-ray work where highest possible speed is needed at available kilovoltage without use of calcium tungstate screens.

Type M—provides maximum radiographic sensitivity with direct exposure or lead-foil screens. It has extra-fine grain and, though speed is less than Type A, it is adequate for light alloys at average kilovoltages and for much million- and multi-million-volt work.

Radiography...another important example of photography at work



RADIOGRAPHY IN MODERN INDUSTRY

A wealth of invaluable data on radiographic principles, practice, and techniques. Profusely illustrated with photographs, colorful drawings, diagrams, and charts. Get a copy from your local x-ray dealer—price, \$3.

EASTMAN KODAK COMPANY
X-ray Division • Rochester 4, N. Y.

Kodak

Personals

Richard C. Hall is now employed as an engineer by the Magnetic Materials Development Laboratory, Westinghouse Electric Corp., Pittsburgh.

Robert J. Bradley has been appointed engineer in charge of the Reading Tube Corp., Long Island City, N. Y.

W. P. Wallace has left his position as senior engineer in the California Research & Development Co., Livermore, Calif., to become senior engineer for General Electric Co., Richland, Wash., in the fuel technology subsection, engineering dept.

Gilbert A. Jones graduated from the University of Illinois in June and is with Owens Corning Fiberglas Corp., Toledo, Ohio, in the metallurgical research department.

Marvin L. Kohn, having received his B.S. degree from Columbia University School of Mines, is now employed at Battelle Memorial Institute as a research engineer in the metallurgy department's welding metallurgy division.

Charles A. Licht, previously employed as special projects engineer at the Cleveland plant of Apex Smelting Co., recently joined the staff at U.S. Reduction Co., East Chicago, Ind., as chief engineer.

Frank D. Dougherty is now employed as a sales engineer with Crucible Steel Co. of America, Newark, N.J. He formerly was assistant to the products manager in the special products division.

E. O. Davis, charter member, has accepted a position with Houston Technical Laboratories, Houston, Texas, as production manager, and will be engaged in the manufacture and exploration of petroleum instrumentation and optical components.

James Albert Perdue has received his B.S. degree in mining engineering (metallurgy option) from Texas Western College and is now affiliated with Phillips Petroleum Co., Tulsa, Okla., as a metallurgical engineer in the test division of the engineering department.

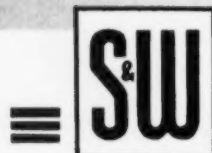
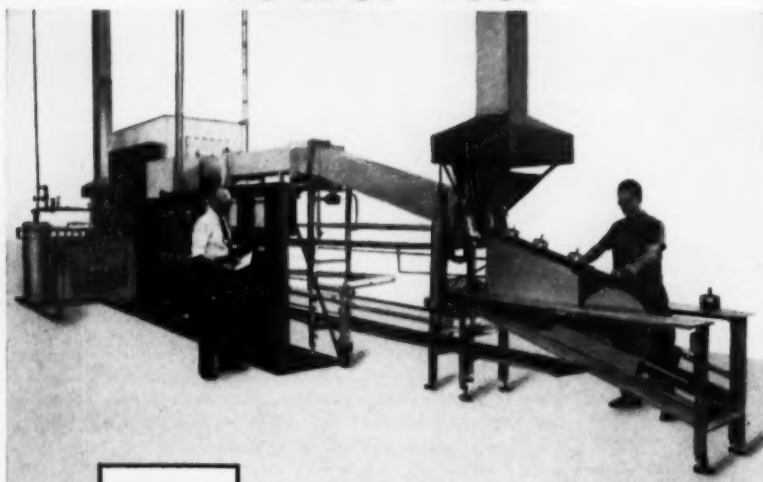
William W. Fetzer received his B.S. in metallurgical engineering from Lehigh University in February and is now employed as metallurgical engineer at the Belle Works of E. I. du Pont de Nemours & Co., Charleston, W. Va.

Robert E. Fish, a recent army inductee, is undergoing basic training at Fort Knox, Ky., and has been assigned to the Army's Scientific & Professional Div.

Edward S. Jones has completed an assignment at the General Electric Research Laboratory in Schenectady, N.Y., and has been transferred to the materials laboratory at G.E.'s Aircraft Gas Turbine Division in Cincinnati.

Lieut. M. L. Anderson, Jr., formerly employed as a sales engineer for Ingersoll-Rand Co., Cleveland, is now attending the aircraft controller's school at Tyndall Air Force Base, Florida, as part of his 2-year tour of duty.

Less atmosphere, lower cost



S&W "A" type furnace used in conjunction with S&W Ammonia Dissociator. Low openings at both ends prevent infiltration of air, seals gases in furnace.

"A" TYPE CONVEYOR FURNACE

In producing brazed or annealed work with a bright surface finish, you can sharply cut operating costs by reducing atmosphere volume required. With this S&W full muffle wire mesh conveyor belt furnace you get uniform high quality production, combined with lower operating cost than is possible with conventional straight-through type furnaces. Of special interest to stainless steel processors, it is particularly suited for such high production heat treating

operations as bright annealing, bright hardening, bright brazing and case hardening. Ask for our interesting data on how this cost-cutting S&W furnace is currently used to do better work at lower cost.

Write today for details on S&W Full Muffle "A" Type Conveyor Furnaces. State your regular requirements — we'll advise without obligation.

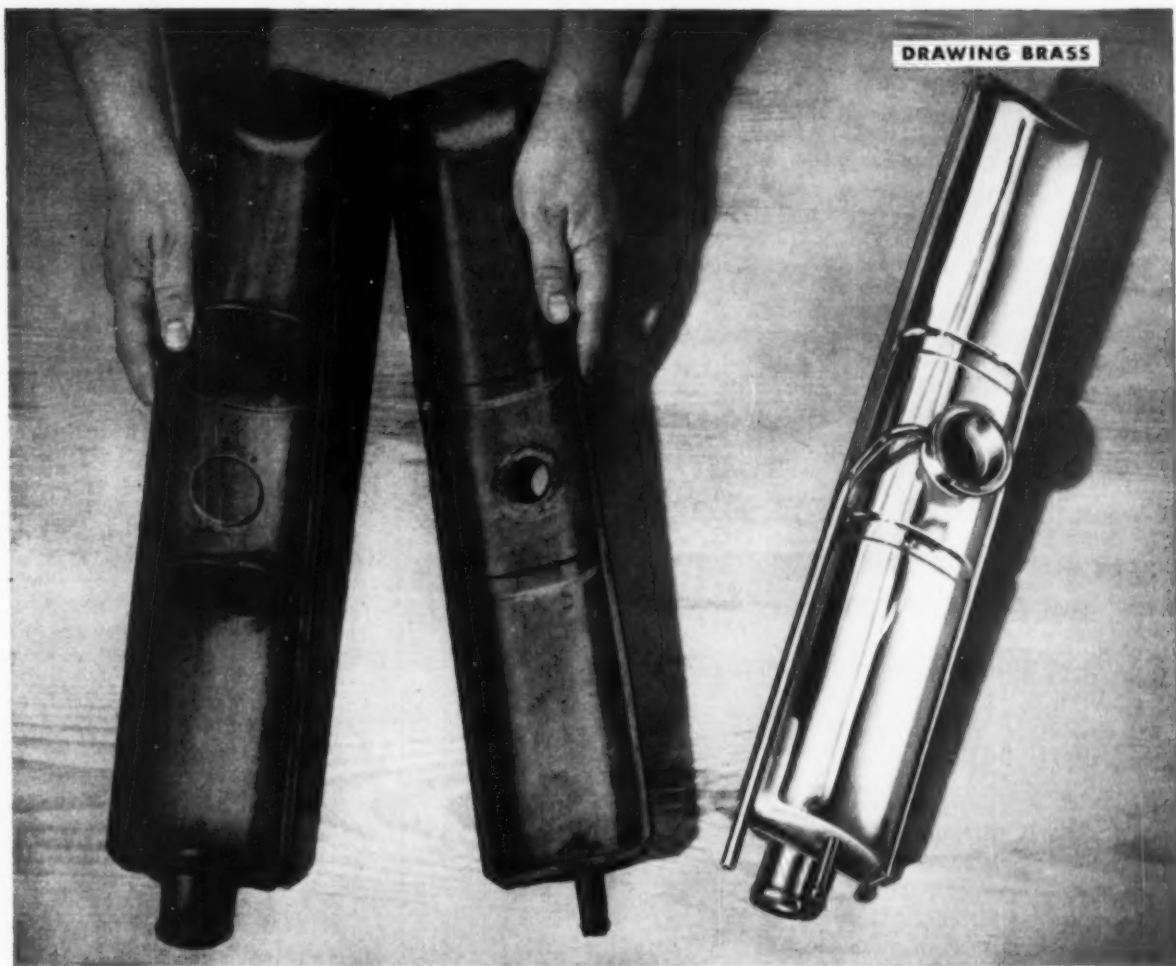
Doors Open 8" Above Belt!

One S&W "A" Type Furnace now used to bright copper braze stainless steels has 8" clearance above belt — contradicting usual belief that working height of constantly opened furnace doors must be less than 3" to get bright work. Ask about other ingenious installations.



SARGEANT & WILBUR, INC.
186 Weeden Street, Pawtucket, R. I.

Complete Line of Electric and Fuel-Fired Furnaces To Meet Every Industrial Need
Atmosphere Generators • Ammonia Dissociators • Gas Conditioning Equipment



RADIATOR TANK made of Formbrite shown before polishing and after chromium plating. Halves are assembled with a lock seam and soldered together with baffles inside. Intake spout, overflow tube and connecting fitting are also attached.

New fine-grain drawing brass cuts rejects from 13% to under 1%

These radiator tanks—used in a leading sports car—were first made of ordinary drawing brass.

But Morrison Steel Products Company, Buffalo, N. Y., found this brass wasn't stiff enough after forming. During handling, polishing and plating, many dents and nicks appeared on the surface. Rejects ran at about 13%.

Then Morrison turned to Formbrite® — Anaconda's new fine-grain drawing brass. Here's what happened.

1. Rejects dropped to less than 1%.
2. Appearance of the final plated tank (very important in a sports car) was so much improved that now Formbrite is specified for all these tanks.
3. Polishing costs were sliced almost in half.

WHY MORRISON FOUND FORMBRITE BETTER, CHEAPER TO USE

Formbrite has a superfine grain. Pro-

duced by special methods of rolling and annealing, this grain is so fine that often a simple color buff brings it to a bright, lustrous finish. (Compare magnification of Formbrite Drawing Brass with that of ordinary drawing brass. At right.)

Formbrite is harder, stiffer, springier and more scratch-resistant. It resists denting and deforming. Yet Formbrite is surprisingly ductile . . . readily stamped, formed, drawn and embossed. And Formbrite plates beautifully.

NO EXTRA COST

Premium price for this premium metal? Not at all. Formbrite costs not a penny more than ordinary drawing brass. It comes in sheets, strips and coils—in all commercial widths and gages.

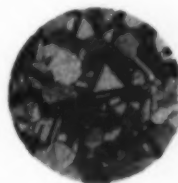
FREE SAMPLE

The way to find out about Formbrite is to try it yourself. Ask for a sample

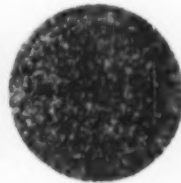
and more information. Just write to: *The American Brass Co., Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ont.*

*Reg. U. S. Pat. Off.

5487



75x magnification of ordinary drawing brass.



75x magnification of superfine-grain Formbrite.

Formbrite

FINE-GRAIN DRAWING BRASS
an ANACONDA® product

Made by
THE AMERICAN BRASS COMPANY

Personals

Thomas M. Baatz ☉, a June graduate from Youngstown College with a degree in metallurgical engineering, is employed at Johnson Bronze Co., New Castle, Pa., in the research laboratory while awaiting his commission as 2nd Lieutenant, U. S. Army Artillery.

David F. Snow ☉, on six months' leave from his job with Bridgeport Brass Co., is serving as director of the copper division, Business and Defense Services Administration, Department of Commerce, Washington, D. C.

Louis J. Fiedler ☉ has graduated from the Chrysler Institute of Engineering as a master of automotive engineering, and is now employed in the metallurgical research department of Chrysler Corp., Detroit.

David R. Shoemaker ☉ has completed his schooling at the University of Tennessee and is now affiliated with Tennessee Eastman Corp. in Kingsport, Tenn.

Herman Gardner ☉ has been transferred from the Wellington, Ohio, plant of the U. S. Plug & Fitting Co. to the Carrollton, Ohio, plant, where he will serve as general manager.

Milton F. Walther ☉ received a B.S. degree in mechanical engineering from the University of Texas in May 1954, and is now employed as a design engineer by the Lufkin Foundry & Machine Co., Lufkin, Tex.

Joseph F. Sisti ☉ has been released from active duty with the United States Navy, and has returned to his former position as metallurgical engineer with the Barber-Colman Co., Rockford, Ill.

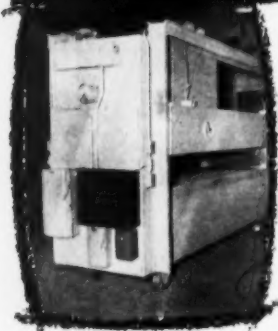
Thomas G. Byrer ☉, who received a B.S. in metallurgical engineering from Ohio State University last June, has accepted a position as metallurgist at the Chase Brass & Copper Co., Euclid, Ohio.

Gerald Abowitz ☉, who holds a Campbell Fellowship for the academic year 1954-55, is now a research assistant in the department of metallurgy at Columbia University.

Dante Accinno ☉, who has been on the staff of the Stevens Institute of Technology for over two years as research assistant on a U.S. Army Signal Corps engineering laboratory project, is still at Stevens, but is now research associate in metallurgy for the Reelshav Div. of Warner-Hudnut, Inc., New York City.

E. C. Larsen ☉ has joined the staff of the J. T. Baker Chemical Co., Phillipsburg, N. J., as technical director, and will be responsible for all research activities and the development of new business. Dr. Larsen was formerly chief engineer of the tungsten and chemical division of Sylvania Electric Products, Inc., Towanda, Pa. Before that, he was assistant research director of the J. T. Baker Chemical Co., and during World War II was on the research staff of the Bell Telephone Laboratories. Dr. Larsen received a B.A. degree from St. Olaf College in Northfield, Minn., and M.S. from Montana School of Mines. He studied in Germany under an international exchange fellowship at the Technische Hochschule Stuttgart; his Ph.D. degree was conferred by University of Wisconsin.

William J. Unterberg ☉ recently resigned from International Harvester Co., Milwaukee, to become assistant chief metallurgist with the Atkins Saw Div. of Borg-Warner Corp., Indianapolis, Ind.



All controls are mounted directly on furnace for easy access. Interwired for direct plug-in to any 220-V line.

Engineered to meet Your Requirements!

Here's your answer to fast, on-the-spot pre-heating for hot forming of magnesium and aluminum sheets. This DESPATCH electrically heated, recirculating type furnace is built for temperature ranges up to 1000° F. Because of its portability it is easily rolled into position for most efficient work. Heat chamber accessible from either side by air operated vertical lift doors. Every furnace engineered and built to meet your particular requirements.

PROCESSING PROBLEM? CALL DESPATCH!

No matter what your heat treating needs may be, Despatch engineers are ready to serve you by offering advice and engineering counsel without obligation. They will help you select the proper equipment to best solve your problem. Call or write to Dept. P.

Minneapolis Office: 619 S.E. 8th St.
Chicago Office: 4554 N. Broadway
Sales and Service in all Principal Cities



These modern metal treating techniques produce outstanding results with Armour Ammonia!

Its economy, dryness and purity (99.98%) make it particularly suitable for many metallurgical applications

CARBONITRIDING

Company metallurgists have found that they are assured a more uniform case by carbonitriding with Armour ammonia. An excellent surface finish is achieved and corrosion resistance is improved. Distortion is reduced, through carbonitriding, due to relatively low temperatures, and carbon and nitrogen concentrations are more accurately controlled. The over-all result is fewer rejects and improved working and safety conditions.

NITRIDING

Precision machine parts such as gears and bushings demand the ultimate in fatigue and friction resistance. The case produced by nitriding with Armour ammonia is harder than that produced by other methods, and is retained for long periods at operating temperatures up to 1100 degrees F. In the nitriding process low temperatures plus the no-quenching factor result in a minimum of distortion. Nitriding has become increasingly important in the last ten years, and Armour ammonia has been generally accepted as the nitride-forming agent.

DISSOCIATED AMMONIA PROCESSES

Protective atmospheres of Armour dissociated ammonia have proved extremely efficient and economical for sintering powdered metals, as well as bright annealing, furnace brazing and other metal treating applications. Dissociated ammonia provides an easily controlled atmosphere at much lower cost than hydrogen. One cylinder of Armour ammonia yields the equivalent of 34 cylinders of hydrogen—and is much less costly!



Save money on our tank truck delivery
service available in most areas

Let Armour help solve your metal treating problems

Manufacturers get more than ammonia when they specify Armour. Since 1947 Armour has sponsored a fellowship at Massachusetts Institute of Technology for the study of metal treating processes using ammonia. The results of this continuous research are available to you. Furthermore the men of the Armour Technical Service Department are equipped to handle and answer any problems arising with ammonia installations for metal treating. Write today for free copies of the booklets offered below. If your problems are unusual or pressing, write giving full details.

CLIP AND MAIL THIS TODAY !

Please send me free copies of the booklets which I have checked:

- ☐ "Ammonia Cylinder Installations for Metal Treating"
- ☐ "Effective Use of Dissociated Ammonia"
- ☐ "Case Hardening of Steel by Nitriding"
- ☐ "A Survey of Industrial Carbonitriding Practice"
- ☐ "Investigation into the Carbonitriding of Plain Carbon Steel"
- ☐ "The Carbonitriding of Alloy Steels"
- ☐ Tank truck service information

Name _____ Title _____

Firm _____

Address _____

City _____ Zone _____ State _____

ARMOUR

Ammonia Division

Armour and Company • 1355 West 31st Street • Chicago 9, Illinois



Aeromaster FANS **ARE** **Granodized** WITH GRANODINE® **FOR EXTRA PROTECTION**

KOPPERS Precision-Engineered Air Delivery increases the efficiency of air flow in industrial cooling systems. Basic element is the Aeromaster Fan, and this unit is operated continuously, sometimes under severe conditions. Dependable, efficient operation is a "must".



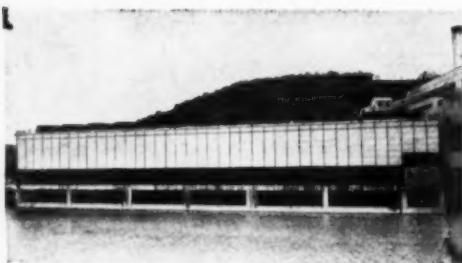
"Granodine" application on welded 54" Hub for Aeromaster 6-bladed 22-foot Cooling Tower Fan

Aeromaster 22-foot Fans provide continuous air flow in C. H. Wheeler Cooling Tower at Pennsylvania Electric Company's Shawville Station, Clearfield, Pa.



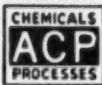
KOPPERS uses "Granodine" No. 50 to coat the 54-inch diameter hub of the 22-foot diameter fan shown above. "Granodine" phosphate coatings provide a "tooth" for adhesion of subsequent finishes and protect the underlying metal so that rust will not spread if these finishes are cracked or nicked.

"Granodine"® anchors the finish.



Pioneering Research and Development Since 1914

AMERICAN CHEMICAL PAINT COMPANY



General Offices: Ambler, Penna.



Detroit, Michigan

Niles, California

Windsor, Ontario

Personals

Ernest F. Nippes, Jr. ☉, has been advanced from associate to full professorship by Rensselaer Polytechnic Institute. Dr. Nippes is director of welding research at Rensselaer and has been engaged in a program of research authorized by the Wright Air Development Center in which he and his associates made experimental investigations into the flash welding of alloy steels.

C. K. Lockwood ☉, vice-president of the stainless steel and alloys division of Shawinigan Chemicals Limited, Montreal, was elected president of the Alloy Casting Institute at the Institute's 14th annual meeting this summer, succeeding **Guy A. Baker** ☉, vice-president of the Duriron Co., Inc., Dayton, Ohio. **E. A. Schoefer** ☉, Mineola, N. Y., was re-elected to serve as executive vice-president and treasurer.

R. O. Hutchison ☉ has joined the Operations Research Division of Lockheed Aircraft Corp., Marietta, Ga., as staff specialist in nuclear engineering. Mr. Hutchison was previously chief project engineer in materials engineering at the Savannah River Operations of the U. S. Atomic Energy Commission in Augusta, Ga.

Howard H. Casey ☉ has been appointed director of engineering at the Midvale Co., Philadelphia, and will head the company's engineering, metallurgical and research staff. A graduate of Drexel Institute of Technology, Mr. Casey joined Midvale in June 1952. Prior to this, he was for 29 years with the Camden (N. J.) Forge Co.

M. L. Backstrom ☉, formerly chief engineer at Firth Sterling, Inc., Pittsburgh, has been promoted to assistant sales manager. He joined the company in 1948 as a sales engineer after three years as a service engineer and assistant chief engineer with Voss Engineering Co., Pittsburgh.

Mattie F. McFadden ☉ is now materials and process engineer with the missile and radar division of Raytheon Mfg. Co., Bedford, Mass. Miss McFadden was formerly engaged in the same type of work for the Norden Laboratories Corp., Milford, Conn.

Case No. 107

Harris Steel Co. Reports:

- 4 Years' Trouble-Free Service
- Constant 24-Hour Operation
- Careful Control of Quality

Bright Annealing Furnaces Use Kemp Atmos Gas Generators to Supply Controlled Atmosphere of Uniform High Quality

Bright annealed steel is produced by Harris Steel Company, Kearny, New Jersey, with the help of two Kemp Model 6-MR Atmos Gas Producers. These two Kemp Generators burn city gas, to supply twelve furnace bases with purified controlled atmosphere.

Treating gas 24 hours a day, seven days a week, each Kemp unit produces 6,000 cfh of gas . . . enough to meet the needs of annealing 4,000 to 5,000 tons of steel per month.

User Reports Complete Satisfaction

Mr. Harry Vane, Plant Superintendent, reports "These Kemp units have been in constant service for 4 years without a bit of trouble. The only maintenance needed has been ordinary routine. Because of the constant purity and qualitative analysis of the gas the Kemp Generators produce, we have been able to secure constant control of color, temper and quality of our output."

Kemp Can Help You, Too

If efficient, carefully-controlled supply of protective atmosphere gas can help you solve production problems, it will pay you to call in a Kemp Engineer for a detailed discussion of your needs. No obligation, of course.

Write to: C. M. KEMP MFG. CO.,
405 E. Oliver Street, Baltimore 2, Maryland.

KEMP OF BALTIMORE

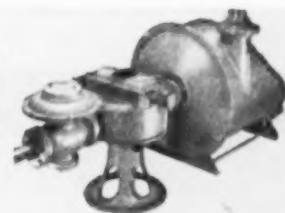


Michael J. Giordano inspects test burner on one of twin Kemp Atmos Gas Producers.



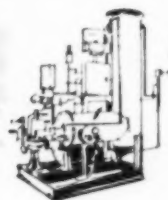
General view of Harris Steel Co. Bright Annealing Department, showing several of the 12 annealing furnaces supplied with Atmos Gas by Kemp Model 6-MR Generators.

This Kemp industrial carburetor—the heart of every Kemp installation—assures the desired analysis of protective atmosphere gas under any demand without waste . . . without frequent adjustments.



ATMOS GAS GENERATORS

ADSORPTIVE DRYERS • SINGEING EQUIPMENT
IMMERSION MELTING POTS
CARBURETORS • BURNERS • FIRE CHECKS



Personals

John P. Frenck has joined the Metals Research Laboratories of the Electro Metallurgical Co., Niagara Falls, N. Y., as a technical assistant in the metals research group. Other ASMembers who have been placed on the same staff recently are **Frank W. Hurd**, **William A. Krivsky**, and **Robert Peterson**. Dr. Hurd has been assigned to the engineering research group as group manager.

James G. Hess, Jr., who received his M.S. in metallurgical engineering from the University of Arizona in May, is now employed as an engineer for the Shell Oil Co., Wilmington, Calif.

Richard H. Stevens, who graduated last spring from Missouri School of Mines and Metallurgy with a B.S. degree in metallurgical engineering, is now with the Aluminum Company of America in the fabricating works at Alcoa, Tenn.

D. I. Dilworth, Jr., director of metallurgy for Crucible Steel Co. of America, has announced the appointment of **E. T. Walton**, formerly chief metallurgist at the company's Midland, Pa., works, to its central metallurgical offices in Pittsburgh in the capacity of metallurgical engineer. Mr. Walton has served with Crucible since 1923 in many administrative and supervisory capacities. **J. D. Dickerson**, chief metallurgist at Midland Works, has assumed Mr. Walton's former duties and will have complete responsibility for all metallurgical and inspection activity at that plant. Prior to joining Crucible in 1953, Mr. Dickerson was chief metallurgist for Republic Steel Corp. in Buffalo.

Henry A. Tobey has been appointed factory manager of the Canton and Gambirius, Ohio, bearing factories of the Timken Roller Bearing Co. Starting with Timken in the metallurgical department in 1928, Mr. Tobey became bearing factory metallurgist in 1940. He was made general superintendent of the Canton bearing division in 1948, a position he retained until his recent promotion.

Frederick H. Warren has been appointed assistant to the executive vice-president, atomic energy division, General Dynamics Corp., Washington, D. C.

Charles R. Wirth has been named district representative for the newly established west coast district office of the Eclipse Fuel Engineering Co., Rockford, Ill. He was formerly a sales engineer in the Rockford area.

Richard J. Rand has been appointed manager of the Cincinnati branch sales office of Crucible Steel Co. of America. Mr. Rand joined Crucible following his graduation from Waynesburg College in 1940, and in 1953 was made assistant manager of the Cincinnati office. In his present capacity, he replaces **H. E. Friedlein**, who will act as special sales representative and consultant. Mr. Friedlein has been associated with Crucible Steel Co. of America for 45 years, and managed the Cincinnati branch for 19 years.

Thomas P. Bellinger is now employed as materials engineer at the Essex Wire Corp., Logansport, Ind.

Standard Alloy

RADIANT TUBE ASSEMBLIES

With Centrifugally Cast Tubes
for EXTRA HOURS of OPERATION



Centrifugal casting of radiant tubes at Standard Alloy is a method backed by years of specialized alloy casting experience as well as machining, and welding operations.

During these years, hundreds of Standard Alloy radiant tube assemblies have been specified by furnace manufacturers, in new furnace equipment, and by furnace operators for replacement units.

You, too, will find Standard Alloy radiant tubes the product of careful alloy selection, and expert workmanship... an assurance of EXTRA HOURS OF FURNACE OPERATION.

Standard Alloy

COMPANY, INCORPORATED

1679 COLLAMER ROAD, CLEVELAND, OHIO

BUFFALO
C. M. Johnson Co.
1007 Elmwood Ave.

INDIANAPOLIS
Wm. McAtee
625 N. DeQuincy

CHICAGO
Elmer A. Terrell
4160 N. Elston Ave.

MILWAUKEE
Boden-Lindgren & Otto
1414 N. 27th

PITTSBURGH
Robert A. Schmidt
404 Frick Bldg.

CLEVELAND
Alloy Sales & Service
Chas. Plant, Jr.
Room 303, 9600 Lake Ave.

NEW YORK CITY
R. Brock Steple
234 W. 31st St.

DETROIT
Schriber & Foreyth
16151 James Cassens Highway

HOUSTON
E. F. Coombs Co.
19179 Katy Rd.

PHILADELPHIA
Towle & Son
18 W. Chelton Ave. Bldg.

LONGMEADOW, MASS.
S. G. Constantine
Central Engineering Co.
51 Converse St.

LOS ANGELES
California Alloy Products Co.
2204 S. Atlantic Blvd.



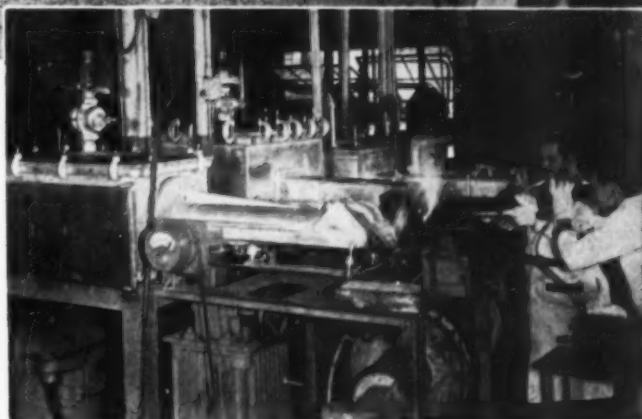
THESE FURNACES are used for sintering of carbide tool tips in a hydrogen atmosphere. The close-up above shows how the furnace is insulated with a mass of alumina bubbles.

Insulation by the shovelful

These furnaces are electrically heated to 2900 - 3000 F by moly wire wrapped around the muffle. The insulation surrounding the muffle is CARBORUNDUM's pure granular alumina — *made in the form of bubbles*. No other insulation is used. None is needed.

Think how easy this makes insulating. No bricks, no cement. Just dump in the bubbles, and the job is done. Later, when the muffle needs replacing, just shovel them out, and then re-use. What could be simpler? And because these bubbles have such a low density, the installed cost is trivial.

The muffle itself also has important advantages. Made of our high-purity, electrically-fused aluminum oxide, it is resistant to extreme heat and is stable in the hydrogen atmosphere used. It is rugged and durable. At this plant, the operator reports a highly satisfactory life.



Our booklet "Super Refractories in Heat Treatment Furnaces" gives dozens of capsule stories like this. It describes actual, profitable applications for CARBORUNDUM's many interesting refractories. Send for your copy today.

CARBORUNDUM

Registered Trademark



Dept. C-94, Refractories Division

The Carborundum Co., Perth Amboy, N. J.

Please send one complimentary copy of your booklet to:

NAME _____ POSITION _____

COMPANY _____

ADDRESS _____

Whatever your furnace needs for control—

There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Just check through the requirements of your specific heat-treating problem . . . then look through this group of instruments and accessories:

Choose **ElectroniK Strip Chart Controllers** for detailed, long-term records . . . and a selection of control forms including electric systems of the con-

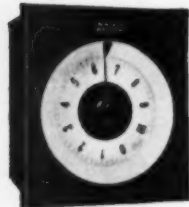


tact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action.

Choose **ElectroniK Circular Chart Controllers** for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.



Choose **ElectroniK Circular Scale Controllers** where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



Choose **Pyr-O-Vane Controllers** where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument.

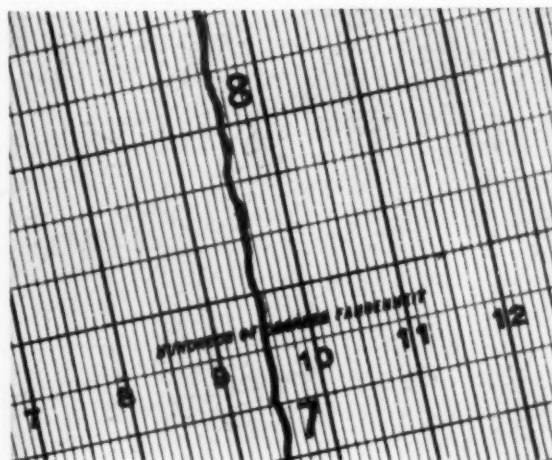


Choose **Protect-O-Vane Controllers** for simple, dependable excess temperature cut-off protection.

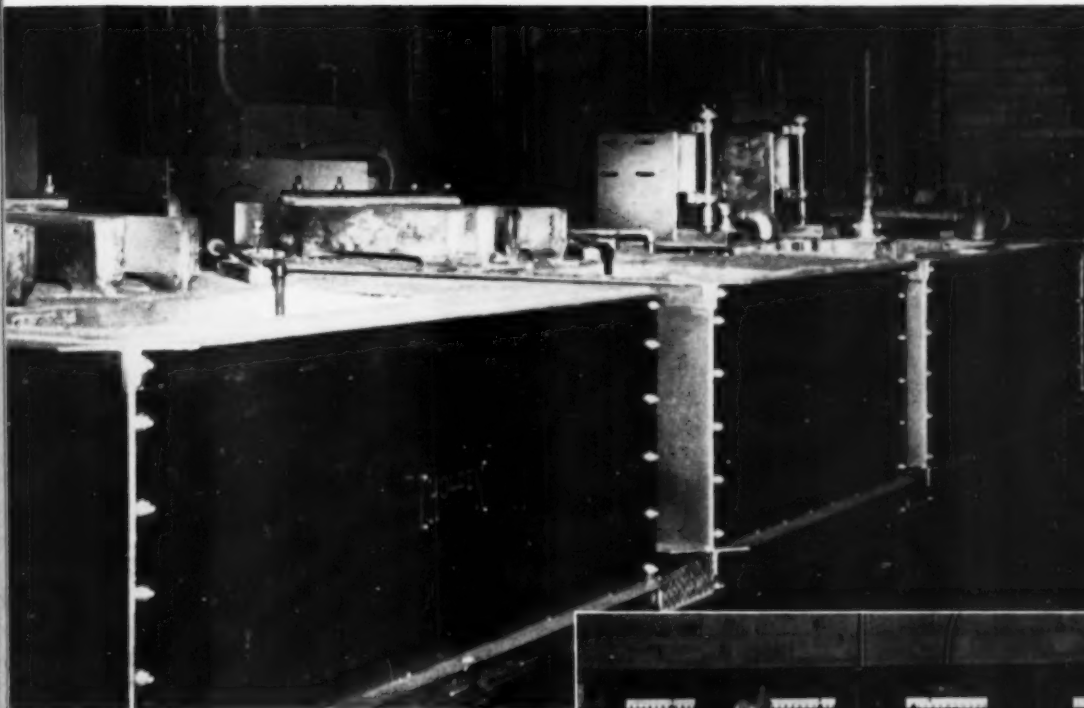


And for all your pyrometer supplies, investigate the HSM Plan—the convenient way to buy the best in supplies on a schedule custom-fitted to your plant . . . at advantageous discount schedules.

Stainless alloys heat-treated accurately in Holden furnaces



Full-size section of a test chart shows how closely temperatures are held in various parts of the bath.



1500 pounds per hour of stainless alloys are heat-treated in these furnaces manufactured by The A. F. Holden Company, each of which is controlled by a strip chart *ElectroniK* instrument on the panel.



with *ElectroniK* control

COOK HEAT TREATING INC., of Los Angeles, makes a specialty of doing difficult heat-treating work on a mass production basis. Their installation of The A. F. Holden Company's salt bath furnaces, equipped with *ElectroniK* temperature controllers, enables them to perform the full gamut of heat-treating operations on any type of stainless steel, including the newest 17-7 and 17-4 alloys, as well as the standard types of alloys.

The furnaces handle a variety of work, including oil well tools, aircraft landing gear parts and large dies. Three of them are electrically heated, and cover useable ranges extending from 325 to 2000° F. The fourth furnace is heated by gas immersion burners. It operates from 350 to 700° F., and is used for mar-quenching.

For each furnace, sensitive *ElectroniK* control regu-

lates heat input to hold temperatures at specified values with exceptional precision. Frequent check runs prove that, throughout the bath and during the entire course of a heat, temperatures stay consistently within a band of only a few degrees. Overall performance of furnace and control is so excellent that military approval for the equipment was promptly obtained.

This installation is typical of the service which *ElectroniK* instruments are rendering in thousands of heat-treating applications throughout the country. For a discussion of how they can help in your own plant, call your nearby Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., Industrial Division, Wayne and Windrim Avenues, Philadelphia 44, Pa.

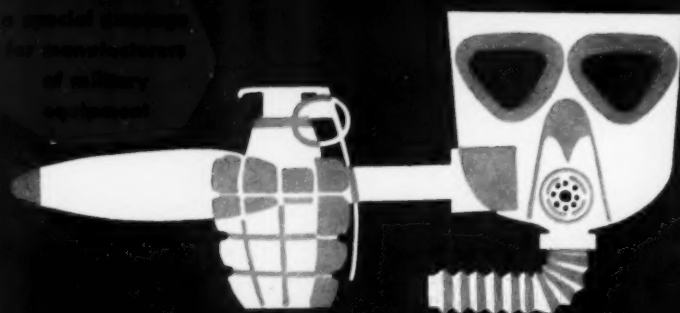
● REFERENCE DATA: Write for Condensed Catalog and Price List No. 54-1, "Furnace and Oven Controls."



MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

a special finish
for maintenance
of military
equipment



need a finish to beat these specs?

specify **IRIDITE**

AN-C-170 MIL-S5002 MIL-C-5541 AN-P32
AMS-2402A USA-50-80-11A J.Q.D. No. 144B
USA 57-93-2A O.S. No. 1374 USA 57-0-2C AN-P61
A-XS-1607 QQ-P-416 QQ-Z-325 MIL-3151—

if you're finishing under these or similar specifications, here's how you can use Iridite:

ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

ON COPPER . . . Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.

ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

ON MAGNESIUM Iridite provides a highly protective film in deepening shades of brown. No boiling, elaborate cleaning or long immersions.

AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

WANT TO KNOW MORE? We'll gladly treat samples or send you complete data. Write direct or call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified telephone book.

ALLIED RESEARCH PRODUCTS
INCORPORATED

4004 06 E MONUMENT STREET • BALTIMORE 5, MD

Representatives of Allied Research Products are available throughout the U.S. and Canada. Write for literature and names of nearest representatives. Also, write for names of nearest representatives in your area.

Lubricants for Non-ferrous Metalworking*

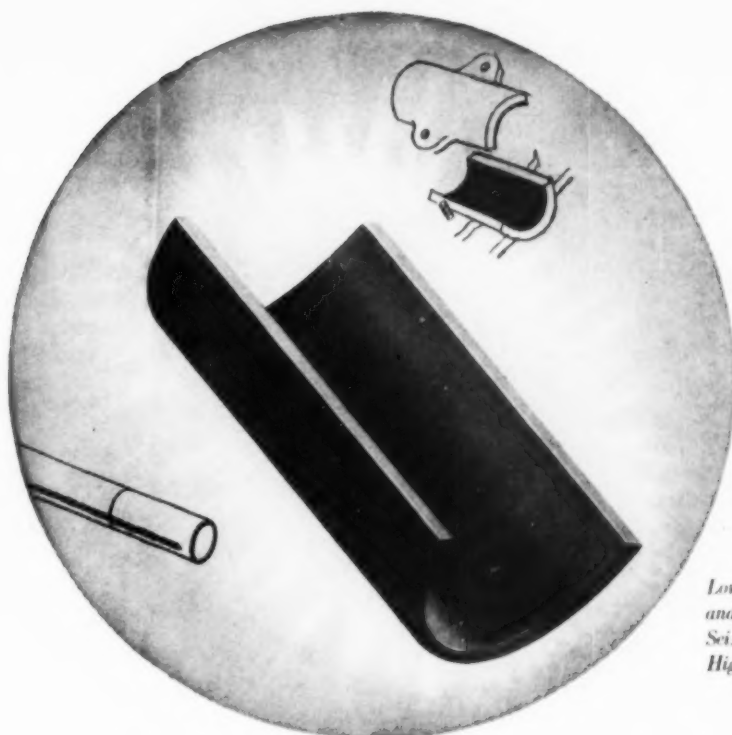
THE INCREASING use of the scientific approach by lubricant suppliers and users and the ever-increasing demand for greater speed of production together with higher standards of quality makes any serious approach to the lubrication problem of interest. Because of this the meeting of the Metallurgical Engineering Committee of the Institute of Metals deserves more than passing attention.

The all-day meeting was carried on as an informal discussion, but unfortunately only a summary of the main points of the discussion is reported. Nevertheless, this summary holds much of interest and constructive suggestion for those engaged in metalworking operations. The morning session was devoted to lubricants for hot working and the afternoon session to cold working.

Underlying principles were discussed in connection with rolling, extrusion and forging, the benefit of wetting agents, and the use of glass fiber. The properties considered desirable in lubricants for cold rolling are described in relation to their function during rolling as well as their subsequent effect—as in annealing or storage—on the strip surface. Some of the problems associated with cold drawing are considered, such as the different requirements imposed on lubricants by types of machines used, kind of metal being drawn, and the speed of drawing. Medium-gage aluminum wire, for example, is now being cold drawn at speeds of 3000 ft. per min. At these higher speeds, higher temperatures are encountered at the wire-die interface and the mineral oils become less effective. It may be that refrigeration of the wire-drawing dies will be the answer; however, the aluminum wire industry must also find a drawing lubricant with the lowest possible viscosity because concurrently with the increase in drawing speeds, the capacity of the lubrication systems and the rate of lubricant circulation have increased.

H. J. ROAST

*Digest of "Lubricants for Metalworking Operations in the Nonferrous Metals Industry", *Journal of the Institute of Metals*, Vol. 82, April 1954, p. 100-104.



*Low Friction Bushings
and Sleeves Resist
Seizing, Abrasion,
High Temperatures*

HAYNES STELLITE Bushings and Sleeves

Trade-Mark

...for handling Hot-Abrasive Materials

Bearing parts made of HAYNES STELLITE alloy resist seizing and galling. They are hard and abrasion resistant, and will withstand the pitting effects of many corrosives. They take a high polish and are easy to apply. Use them to reclaim worn shafts or bearing blocks, and to lengthen the life of new equipment.

Operate with Little or No Lubrication

Sleeves made of HAYNES STELLITE alloy can be used in areas where efficient lubrication is impossible. They resist seizing even when lubricants are diluted by gasoline, cleaning fluids, and other liquids that wash out an oil film. They operate at peak efficiency even when lubricants decompose under heat, or are destroyed by abrasive particles.

Tough and Abrasion-Resistant

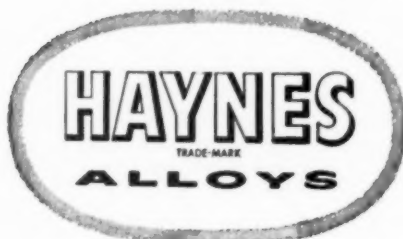
Bearing parts made of HAYNES STELLITE alloy resist the abrasive effects of wet or dry materials such as fly ash, coke, metal powder, shale, and cement dust. They are hard enough to carry heavy loads, and tough enough to stand up under repeated stress.

Heat and Corrosion Resistant

These bushings and sleeves can be submerged in many acids, alkalies, and molten metals. Temperatures as high as 1500 deg. F. have little effect on their hardness, toughness, and dimensional stability.

For more information write for our 8 page booklet on half bushings and sleeves.

"Haynes" and "Haynes Stellite" are registered trade-marks of Union Carbide and Carbon Corporation.



HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation



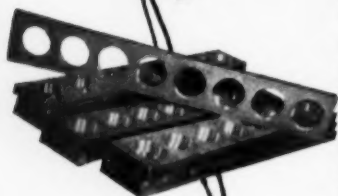
General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa



Get what you want in
STAINLESS STEELS
right from G.O. Carlson, Inc.



The best way to buy stainless steel—plates, forgings, heads, rings, flanges, bars—is from the "one order" source, G. O. Carlson, Inc. Here at Carlson every item of your order is accurately produced, specifications are matched exactly, delivery promises are met. This control of each detail satisfies customers because it saves them extra paper work, extra stock handling and holds to their production schedules.

Carlson technical and practical experience, coupled with the use of specialized, high production equipment, provide an efficient packaged service. Your order for stainless steel plate and other stainless items is handled quickly, easily and economically.

To cut costs and eliminate confusion—check Carlson first! Your inquiry will receive prompt attention.

G.O. CARLSON, INC.
Stainless Steels Exclusively
Plates • Plate Products • Forgings • Bars • Sheets (No. 1 Finish)

THORNDALE, PENNSYLVANIA

District Sales Offices in Principal Cities

Vitreous Enameling Keeps Pace With Production Practices*

PORCELAIN enamel finishes on sheet steel have come into widespread use on many varieties of consumer goods, including refrigerator linings, tops and oven linings of kitchen ranges, clothes washers and driers, water heater tanks, bathroom equipment, telephone dials, store fronts, gasoline pumps, signs and others. Recently the commercial enameling of aluminum has been introduced for architectural and industrial uses.

The finish, perhaps more accurately described as a vitreous enamel, is a fired glass coating. Originally it was produced by a dry process, involving the dusting of heated metal parts with glass powder and then returning them to a furnace for firing. Now it is universally handled by a wet process in which the powdered glass is suspended in a mixture of water and clay and applied to parts by dipping or spraying.

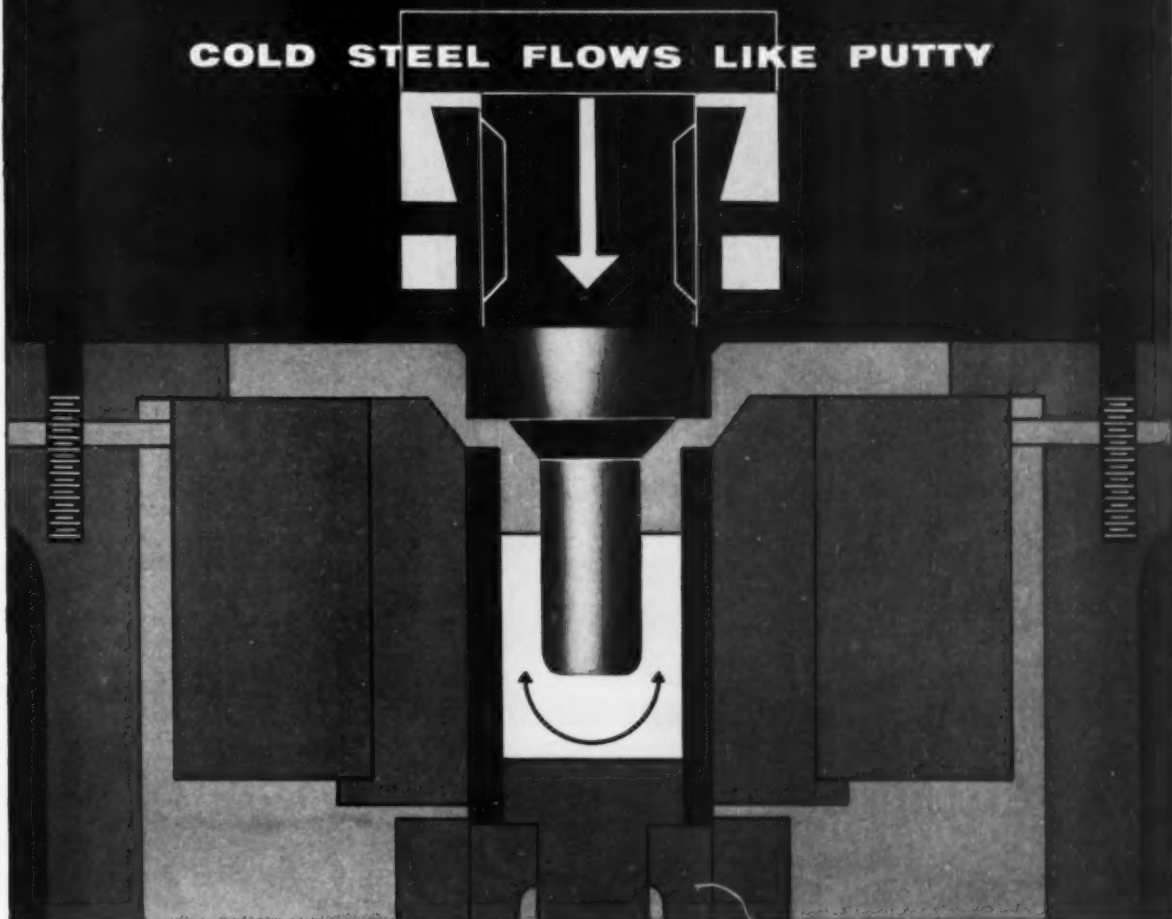
Since the enamel coating is glass, it acts as an impervious barrier, protecting the base metal unless disrupted in some manner, as by impact, bending, scratching or abrading. Once fracture occurs, the enamel cannot be restored. High resistance to most forms of chemical attack is characteristic.

Parts for household appliances usually are formed from steel sheets, ranging from 17-gage to 24-gage, a common grade being enameling iron, containing 0.01 to 0.04% C, a maximum of 0.1% Mn and a minimum of residuals. Such sheet stock has uniformly good strength at high temperatures, seldom gives rise to defects in the enamel and has a special surface texture suited to easy application and good adherence.

Difference in characteristics of various porcelain enamels is determined by the enamel glass, no single type incorporating all the desired qualities. Thus several varieties are mixed together in formulation of commercial frits. Principal glass-forming materials are silica sand, (Continued on p. 148)

*Digest of "Porcelain Enamel: Its Use and Manufacture for Household Appliances", by Wilbur H. Pfeiffer, *General Motors Engineering Journal*, Vol. 1, No. 6, May-June 1954, p. 8-13.

COLD STEEL FLOWS LIKE PUTTY



A vital new metal shaping method is now practical with the Pennsalt Fos Process . . . tubes, shafts, cylinders, gear blanks, piston pins, and other shapes can now be cold formed in presses. This eliminates up to 80% of all machining formerly required . . . produces better parts, faster, for less.

The Pennsalt Fos Process is now being used in automotive, tube, wire drawing, and ordnance plants. The process includes a new Pennsalt lubricant and a proven method of locking the lubricant to the steel.

The Fos Process insures the smooth and rapid flow of cold steel through the die, even at extreme pressures.

Practically all of the original metal can be utilized with Pennsalt cold extrusion techniques . . . work cycles can be reduced . . . and over-all production speeded up. Superior physicals can be obtained from carbon steels, along with a better, smoother finish. Multiple draws without interim recoating and annealing, and greater reductions per draw are now practical.

Write today for the complete story,

or send us blueprints of products you are interested in. Metal Processing Department, Pennsylvania Salt Manufacturing Company, 506 Widener Building, Philadelphia 7, Pa.



PENNSYLVANIA SALT MANUFACTURING COMPANY

SEPTEMBER 1954; PAGE 147

idea for *AUTOMATION*

with **CAMBRIDGE**
Woven Wire Conveyor Belts

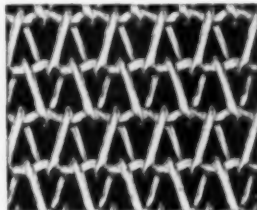
◎ *CONTINUOUS BRAZING* ◎

Metal products can be heat treated, quenched and cooled in one continuous series of operations on Cambridge belts. All-metal belt is unharmed by temperature, quench oils or sharp-edged, heavy loads. If you're still heat-treating by costly, time-wasting batch operations you'll find Cambridge Woven Wire Conveyor Belts help provide cost-cutting, automatic production by allowing you to process the work continuously. No batch operations, less manual handling for such processes as: annealing, tempering, brazing, sintering, soldering, as well as quenching, pickling, oiling, washing.

OPEN MESH CONSTRUCTION of the belt provides free circulation of heat-treating atmospheres for uniform processing, free drainage of process solutions. Of course, the all-metal construction means lowest maintenance cost.

CAMBRIDGE BELTS are available in any metal or alloy. Thus, the belt recommended for you can be fabricated from the specific material that will give longest belt life under your operating conditions. In addition, Cambridge belts can be woven to any length or width and in a wide variety of weaves and mesh sizes to meet your needs.

FREE REFERENCE MANUAL gives full details on how Cambridge belts can boost output, cut costs by providing continuous, automatic production . . . automation! Includes all specifications and details, also metallurgical tables. Write for your copy today! Or, for specific recommendations, call in your Cambridge Field Engineer. He's listed under "Belting-Mechanical" in your classified 'phone book.



The Cambridge Wire Cloth Co.

WIRE
CLOTH

METAL
CONVEYOR
BELTS

SPECIAL
METAL
FABRICATIONS

Department B

Cambridge 9, Maryland

OFFICES IN LEADING INDUSTRIAL AREAS

Enameling . . .

feldspar, borax, fluorspar, cryolite, sodium silicofluoride, alumina, zinc oxide, soda ash, sodium nitrate, barium carbonate, lithium carbonate.

Combinations of some of these, predominantly silica, borax and feldspar, are used to produce clear colorless glasses, while in other instances coloring materials are added to form dark colored enamel frits. Cobalt, nickel and manganese oxides are added for ground-coat enamels; antimony, zirconium or titanium oxides may be added for white cover coats. Titanium-type white enamel is now in general use for most appliances.

Enamel is prepared by mixing the frit with water and relatively small amounts of clay and chemicals in a ball mill and grinding until almost all of the mixture passes 200 mesh. Successful application depends upon qualities of the clays. The latter must hold the frit particles in suspension until applied to the steel; they must hold the coating on the parts until firing is completed, and they must go into solution in the enamel glass during fusion, without discoloration.

While research is being directed toward some means of dispensing with the need for both ground and cover coats, general practice still is to apply the two, the ground coat to both sides of parts and the cover coat, by spraying, to one side only. Ground coats are fired usually from 3 to 4 min. at 1500° F. and cover coats from 2 to 3 min. at 20 to 50° lower temperature.

Time and temperature are rather critical, since they must be sufficient to dissolve clay and chemicals in the enamel, dispose of gases, develop a smooth surface and permit titanium compounds to crystallize or the colorants to reach the correct condition. At the same time, they must not be of a degree which would cause excessive acidity in the ground coat, or lead to solution of colorants or precipitation of the titanium oxides in an unfavorable form.

Titanium dioxide is the most effective whitener or opacifier known for porcelain enamel, but its value depends upon proper crystallization from the glass. The crystallites should be wholly or predominantly of the anatase form and not rutile, (Continued on p. 150)

ROLOCK

FABRICATED

ALLOYS

HEAT AND CORROSION
RESISTANT



FORD MOTOR COMPANY

SAVES ½ HOUR IN HEAT TREATING CYCLE

Photographs above show two similar cycles through a roller hearth carbo-nitriding furnace at 1500° F., followed by oil quench . . . at the Rouge Dearborn Engine Plant. (Left) Rolock fabricated hairpin fixtures and pressure-welded separator screens carry Crankshaft Sprockets, while (right) Rolock fabricated stacking-type fixtures handle Oil Pump Shafts (long and short).

In both instances, through individual positioning, cycle times have been reduced ½ hour from bulk loading times: for the sprockets, from 3 hours to 2½ . . . and, for the shafts, from 2 hours to 1½. Optimum circulation of gases and quenching oil around parts improves quality . . . positioning shafts vertically minimizes run-out . . . loading and unloading are simplified.

Rolock fabricated, engineered-to-the-job heat treating equipment cuts costs . . . better your competitive position . . . improves your products. Rolock engineers expect, and welcome, tough jobs . . . and are solving them for the country's leading metal-working plants. Our Catalogs B-8 and B-9 are packed with ideas you can use. Send for them today.

Offices in: ANDERSON, IND., CHICAGO, CLEVELAND, DETROIT, HOUSTON, LOS ANGELES, MINNEAPOLIS, PHILADELPHIA, PITTSBURGH, ST. LOUIS

ROLOCK INC. • 1222 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

DR.L.56A

SEPTEMBER 1954; PAGE 149

NEW BOWSER "T" UNITS FOR TESTING, STORAGE AND PROCESSING



Whatever your application of cold treatment . . . shrink fitting, conditioning or storage of materials, testing of electronic equipment, or other use . . . you'll appreciate the many advanced engineering features of these new Bowser units.

Compact, light weight, ruggedly constructed, they feature wide temperature range and rapid pull-down. Semi-hermetic compressors eliminate needless bulk, provide for years of trouble-free operation. All units are factory tested under conditions simulating those in the customer's own plant. The Bowser sales engineer in your area will be glad to help on your cold treatment problem.

These new Bowser units are available for prompt delivery . . . at a surprisingly low price.

Write today for complete information.



BOWSER TECHNICAL REFRIGERATION

DIVISION OF BOWSER INC. TERRYVILLE, CONNECTICUT

METAL PROGRESS; PAGE 150

Enameling . . .

since spectral reflectance of rutile is low at wave lengths below 420 microns, causing a yellow tone. Particle size also is important, those of 0.16 to 0.18 micron being blue, 0.32 to 0.45 micron yellow and 0.20 to 0.25 micron nearly neutral or achromatic.

When a ground coat is applied to sheet steel and fired, the following sequence of events occurs: The metal surface oxidizes; clay and some of the chemicals dehydrate; metal and glass give off gases; hydrogen is absorbed by the metal; melted glass dissolves iron oxide, clay and chemicals; melted glass wets the metal; dissolved iron oxide and bubbles migrate through the molten enamel; and stresses in the metal become relieved, with the metal distorting because of the differential heating and the pull of gravity.

As the parts cool, the glass re-absorbs gases and solidifies. Stresses and strains develop from the differential cooling and contraction between metal and enamel. Hydrogen becomes less soluble in the iron, resulting in pressures tending to force the enamel away from the metal surface. With insufficient adherence of the coating, this hydrogen pressure will disrupt the enamel in a circular area, producing a half-moon fracture commonly called fishscaling. This may not occur for several weeks after the metal has been enameled.

Another factor of top importance in the enamel-metal system derives from the fact that glass is strong in compression but weak in tension. Consequently, frit compositions are selected to give an enamel which will contract less than the base metal during cooling, leaving it in a state of compression. When a strain is imposed thereafter, it either creates more compression or it is absorbed in relieving compression so that failure does not result unless the strain is excessive, as in sharp bending, torsion or impact.

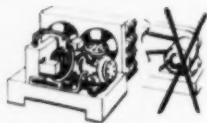
Ground coat thicknesses usually are in the range from 0.003 to 0.0045 in. For satisfactory appearance, white enamel exterior coats on appliances must reflect at least 75% of all visible light they receive. With titanium-type frits, this requirement can be met by thicknesses of 0.0025 to 0.005 in.

A. H. ALLEN

BOWSER



Available with caster assembly for portable operation.



Semi-hermetic compressors reduce bulk, insure trouble-free operation.



Fan and coil arrangement permits air circulation within the chamber.

*King
Size*
BOILERS



Big boilers for utilities and general manufacturing? B-L's tube supported wall design and Texad* finishes eliminate enclosure structural steel and steel plate casings. That saves plenty on the original cost! Performance? Better than ever!

BIGELOW-LIPTAK Corporation
UNIT-SUSPENDED WALLS AND ARCHES

**Tougher
Than
Blazes**



City incinerators are natural applications for B-L unit-suspended walls and arches. Installations dot the country—are literally "tougher than blazes." Why? Because they are individually designed for the job.

BIGELOW-LIPTAK Corporation
UNIT-SUSPENDED WALLS AND ARCHES

Versatility

You'll find that versatility is an inherent quality in B-L's design for furnace walls and arches. Thermal problems—erosion hazards—desired end results—are factors that govern the final design. That's why you see so many B-L installations through industry. After all, they provide long, dependable service at a low, low cost. More information? Write today.

**LEADS
WITH
ITS
NOSE**



High temperatures in metal working make any billet-heating furnace a tough problem. This B-L free-floating nose design controls expansion at a vulnerable point—the nose. That flexibility accrues only from unit-suspended construction.

BIGELOW-LIPTAK Corporation
UNIT-SUSPENDED WALLS AND ARCHES

*REGISTERED TRADE MARK



BIGELOW-LIPTAK Corporation

AND BIGELOW-LIPTAK EXPORT CORPORATION

2550 WEST GRAND BOULEVARD, DETROIT 8, MICHIGAN

UNIT-SUSPENDED WALLS AND ARCHES

In Canada: BIGELOW-LIPTAK OF CANADA, LTD., Toronto, Ontario

ATLANTA • BOSTON • BUFFALO • CHICAGO • CINCINNATI • CLEVELAND • DENVER • HOUSTON • KANSAS CITY, MO. • LOS ANGELES • MINNEAPOLIS • NEW YORK
PITTSBURGH • PORTLAND, ORE. • ST. LOUIS • ST. PAUL • SALT LAKE CITY • SAN FRANCISCO • SAULT STE. MARIE, MICH. • SEATTLE • TULSA • VANCOUVER, B.C.



LET THIS NEW WESTINGHOUSE CATALOG INCREASE X-RAY EFFICIENCY

Better, cheaper, faster radiographic testing is a product of trained personnel plus proper equipment.

The new Westinghouse Industrial Supplies and Accessories Catalog has 44 pages listing over 600 items of film, chemicals, equipment, tools, and devices. The advantages and uses of each product are carefully explained.

In initiating, expanding, or re-

furbishing your radiographic program, call your nearest Westinghouse X-ray office (listed in the catalog or your phone book). There you will find men of wide experience who can help you toward an efficient, modestly priced arrangement.

Use the coupon or call your Westinghouse X-ray representative for a copy. It means faster, cheaper, better radiographs.

YOU CAN BE SURE...IF IT'S

Westinghouse

Westinghouse Electric Corporation
X-ray Division, Dept. O-66
2519 Wilkens Avenue
Baltimore 3, Maryland

Gentlemen: —

Please send me a copy of the new booklet "Industrial X-ray Supplies and Accessories."

Name Title

Company

Street

City Zone State

J-08266

Castings for Aircraft*

IN TWO articles the Dayton editorial representative of *Aviation Age* discusses the possibility that the foundry art may be so modified and improved by modern techniques as to compete with forged parts or bit-by-bit fabrications, and usher in a revolution in the manufacture of large aircraft. Either of these alternatives will cause a severe bottleneck if aircraft production schedules are sharply enlarged, either because of shortages of equipment or trained personnel.

In 1947 the U.S. Navy Bureau of Aeronautics and Bureau of Ships started a comprehensive research into molding, melting and casting methods at Champaign, Ill., along lines already outlined in "Critical Points" in *Metal Progress* for July 1949. About three years ago, a limited survey on the possibility of using stressed castings in aircraft was authorized by the U.S. Army Air Forces, and later extended both in time and scope. The principal goals for this "Casting Potentials Project" are:

1. Compilation of a manual or handbook about castings and cast metal for designers in the aircraft industry.

2. Redesign of certain components of landing gear.

3. Their experimental casting by advanced foundry techniques.

4. A complete program of tests on these castings.

5. Pilot plant production of these proven components.

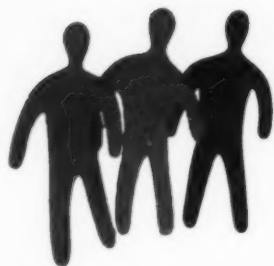
6. Evaluation of over-all costs in large-scale production.

In addition to existing facilities for pilot plant production, jointly owned by the contractor (Alloy Engineering & Casting Co.) and the U.S. Navy, a complete laboratory for stress analysis and full-scale testing is being installed.

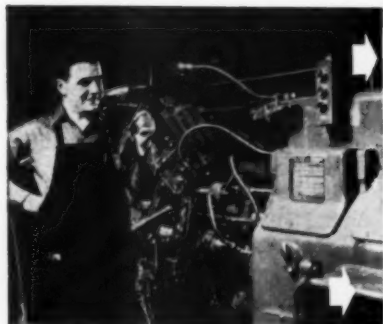
To indicate the method of attack, a main landing gear trunion may be cited, conventionally made of forged A.A. 2014-T (14 S-T) aluminum alloy (56,000 psi. yield at 0.2% offset, 80,000 psi. ultimate, 9.5% elongation at fracture). The arm, shaped like a bell crank, is of I-beam cross

(Continued on p. 154)

*Digest of "Casting Potentials", by Lon C. Kappel, *Aviation Age*, May and June, 1954.



HERE'S WHAT HAPPENS WHEN REPUBLIC'S **3-D** METALLURGICAL SERVICE GOES INTO ACTION



The field metallurgist comes right into your plant. He checks furnace temperatures and heating cycles, machines, set-ups, feeds, speeds, everything which affects your production.



He talks to your plant and engineering people, asks questions, finds out what you want your alloy steels to do. He takes this data with him.



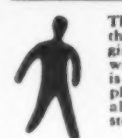
The Republic Field Metallurgist talks over his report with Republic's Mill Metallurgist. Experienced in producing alloy steels, he adds his knowledge, checks it against your problem. And since Republic controls its alloy steels from ore to finished product, he can trace heats of steel.



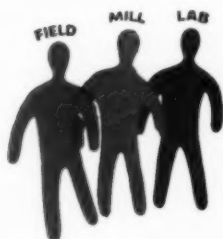
The field metallurgist next talks things over with the Republic Laboratory Metallurgist. His data on tests of alloy steels is added to the material of the field and mill metallurgist.



Then, all three men put their heads together and come up with a recommendation that is the result of pooling their findings and their experience with alloy steels. And since Republic pioneered the manufacture of alloy steels, this recommendation is based on solid data.



The Republic Field Metallurgist passes this recommendation on to your engineers and plant personnel. He works with them to see that your problem is solved satisfactorily, right in your plant. It's his job to see that you get all the advantages out of the alloy steels you use.



The results often include lower production costs, better quality, or even changes in design. You can have this free service by calling your local Republic Steel sales office.

REPUBLIC STEEL CORPORATION

Alloy Steel Division • Massillon, Ohio

GENERAL OFFICES • CLEVELAND 1, OHIO

Export Dept.: Chrysler Bldg., New York 17, N.Y.



Other Republic Products Include Carbon and Stainless Steels—Sheets, Strip, Plates, Pipe, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing.

for Efficient Heat Treating

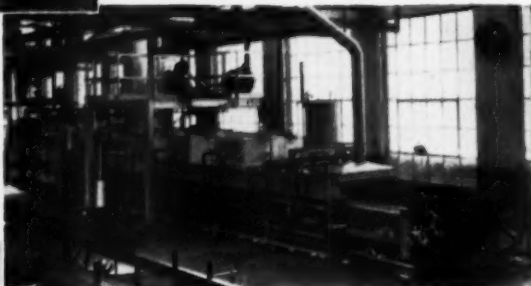
install

ROCKWELL FURNACES & OVENS

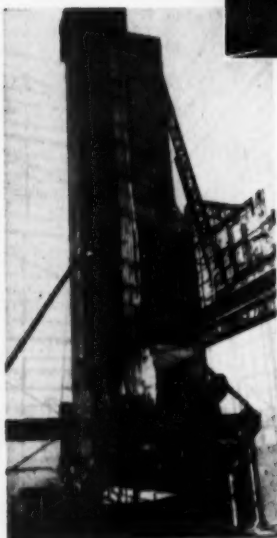
Gas • Oil • Electric
Batch or Continuous



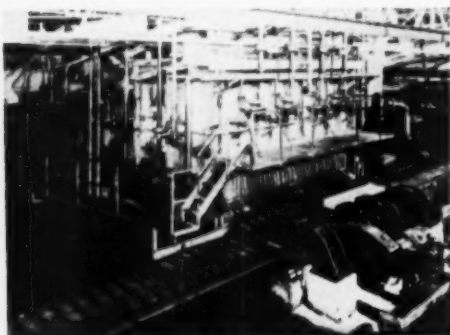
Car type, recirculating furnaces for annealing steel castings and forgings.



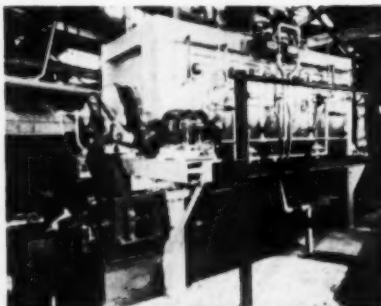
Continuous belt conveyor, atmosphere controlled furnace for bright annealing non-ferrous tubing.



Vertical oven for solution heating large aluminum extrusions.



Continuous copper cake heating furnace; production—to 40,000 lbs. per hour.



Revolving retort furnace for hardening small steel products.

Write for Catalog on
Rockwell Furnaces & Ovens



W. S. ROCKWELL COMPANY

FURNACES • OVENS • BURNERS • VALVES • SPECIAL MACHINERY

2044 ELIOT STREET • FAIRFIELD, CONN.

Sales Representatives in Principal Cities

Aircraft Castings...

section—a shape readily forged but difficult to cast without internal flaws or stress concentration because of the accumulation of metal at intersections of web and flanges. In redesign for casting, this arm is a tapered tube, and the part is cast of aluminum alloy 220TA (49,000 psi. yield at 0.2% offset, 63,000 psi. ultimate, 4.5% elongation). At the test load of 4000 lb., the highest stressed region of the forging—at the bend in the arm—carries 70,000 psi., well past the yield and within 10,000 psi. of the breaking point, and is at an indicated true strain of 3.3%; in cast design and construction the highest stress at the bend in the arm is 52,000 psi. and at an indicated true strain of 1.0%.

Another landing gear trunion conventionally forged of aluminum with I-beam arm and weighing 60 lb., was redesigned and cast of alloy steel with tubular arms. The latter was heat treated to 170,000 psi. ultimate. The strength-weight ratios of the two designs are equal.

At present, cast parts are shunned by aircraft constructors. A survey made by the Aircraft Industry Assoc. indicated that their reasons are (a) low physical properties of castings, (b) poor quality, (c) inability to cast thin sections, (d) low strength-to-weight ratio, (e) low ductility, (f) poor dimensional tolerances, (g) poor inspection and control. The project under way is based on the assumption that these impediments are inherited from past experience with the product of commercial foundries which have small incentive to meet aircraft requirements and which are in fact using traditional techniques inherently responsible for poor quality and uniformity, and on the further premise that drastic changes in molding materials and methods, improvements in melting methods to avoid gas absorption or inclusions, and casting techniques which control feeding and cooling rates in all regions of the part will produce cast parts of high and uniform integrity and of utmost reliability in service.

The most recent survey of the Aircraft Industry Assoc. reports that "when improved castings approach forgings in strength and other fac-
(Continued on p. 156)

When Should Alloy Steels Be Ordered to Hardenability?

This is the fifth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

What is hardenability and how does it differ in carbon and alloy steels?

Hardenability can be defined as the capacity of steel to develop a desired degree of hardness, usually measured in depth. It is produced by special heating and cooling. Carbon steel, except in small sections, will normally harden to a depth slightly below its surface, while alloy steel can, under certain conditions, harden uniformly through its entire cross-section.

Surface hardness obtainable after quenching is largely a function of the carbon content of the steel. Depth hardness, on the other hand, is the result of alloying elements and grain size, in addition to the carbon present in the steel.

In general, where hardenability is the prime consideration, it is not too important which alloy steel is used, just as long as there is sufficient carbon present to give the prescribed hardness, and enough alloying elements to quench out the section. We might mention here that it is not considered good practice to alloy a small section excessively, since too free a use of alloying elements adds little to the properties

and can, in some instances, induce susceptibility to quenching cracks.

There are, of course, numerous cases where factors other than hardenability must be considered; such factors as low-temperature impact, heavy shock, creep-resistance, and the ability to resist temper brittleness. Through-hardening, therefore, is not always desirable. For example, shallow hardening is often necessary in shock applications, because a moderately soft core is essential.

Our metallurgists will gladly explain where it is advantageous to order alloy steels to hardenability, and where it is preferable to order by analysis. They will also give you any help you may require in connection with heat-treating and machining problems.

And when in need of steels, remember that Bethlehem manufactures the entire range of AISI standard alloy grades, as well as special-analysis steels and all carbon grades. We can meet your needs promptly.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

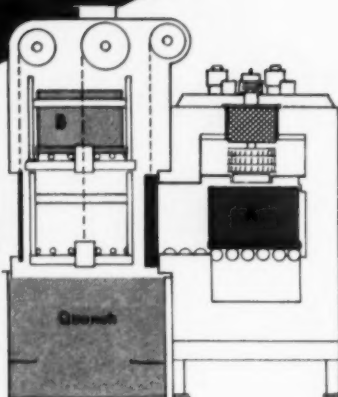
BETHLEHEM *ALLOY* **STEELS**



Sealed Cycle.... A Dow Furnace FIRST for Batch-type controlled atmosphere furnaces.

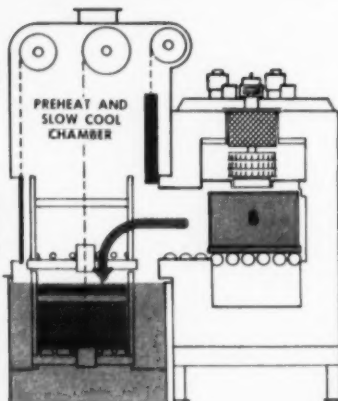
Step 1—LOADING CYCLE

Box A containing full furnace load of parts processing in work chamber. Box B—fully loaded, pre-heats in the upper vestibule. Box C—fully-loaded, waits on conveyor.



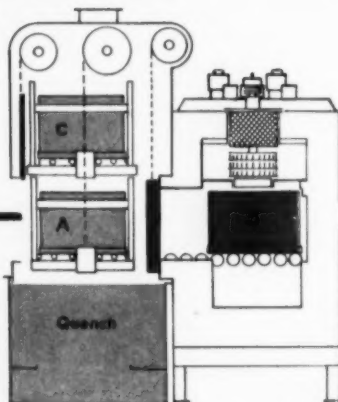
Step 2—QUENCHING CYCLE

Box A completely processed, moves out to elevator and is lowered into quench; bringing pre-heated Box B to loading level. Box B is pushed into heat chamber and door is closed.



Step 3—RELOADING CYCLE

After proper interval, outer door is opened. Box C is placed on upper elevator and raised to pre-heat position as Box A is lifted from quench and removed from lower elevator.



Sealed Cycles; double door seal affords complete flexibility of processing without exposing heat chamber to air contamination.

Upper vestibule is easily adapted for slow cooling. Quench is adaptable for interrupted quenching.

First WITH
MECHANIZED, BATCH-
TYPE, CONTROLLED
ATMOSPHERE FURNACES

12045 Woodbine Ave., Detroit 28, Mich.
Phone: KEnwood 2-9100

Aircraft Castings . . .

tors and when large castings of precise dimensions are available, there should be a greatly increased usage for structural parts of all sizes, from landing gears to wings", and comments that this would be especially true when the parts reach unmanageable size if present production techniques are still employed.

E.E.T.

Some Factors Which Affect Quality of Iron Ore Sinters*

THE HIGHLY complex nature of the sintering process as applied to iron ores is revealed in this paper. The development of thin-section radiography has opened new possibilities of studies in this field, and some of the observations made with this new technique on various iron ore sinters are reported herein.

An iron ore sinter may be regarded as consisting of three fundamental types of structural constituents:

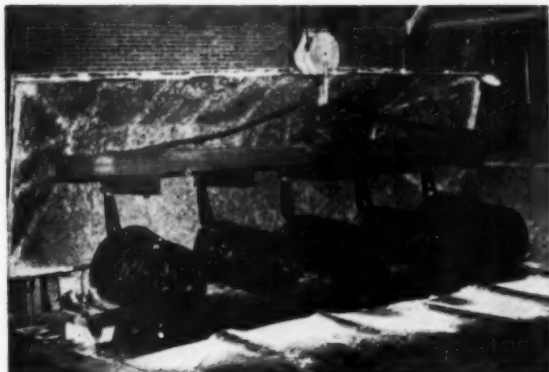
1. Original minerals which have remained unaltered throughout the sintering treatment.
2. Original mineral constituents which have readjusted their structure and shape by recrystallization in the solid state. These do not lose their chemical or physical identity at any time during or after the sintering process.
3. Secondary constituents which result from material that is fused or dissolved during sintering. These may be constituents which remain dissolved in a glassy slag or which crystallize on cooling in the form of fully developed dendritic crystals.

The main purpose of sintering is to produce large and physically strong aggregates with high porosity by bonding together fine ore particles. Two types of bonding are theoretically possible: bonding by diffusion and recrystallization of the fine ore fragments under the influence of heat, and bonding by slag formation by melting of easily fused constituents.

(Continued on p. 158)

*Digest of "Sintering of Iron Ores", by E. Cohen, *Iron & Steel*, Vol. 26, Dec. 11, 1953, p. 620-624.

Descaling 5 tons of stainless wire *IN 15 MINUTES* with VIRGO® Descaling Salt



10-MINUTE IMMERSION in molten bath of Virgo Descaling Salt at 900°F. loosens scale. The bath is self-regenerating, and produces no toxic fumes. Immersion time and temperature are flexible, need not be watched closely.



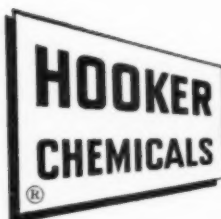
WATER QUENCH removes much of the loose scale. The steam generated by immersing the hot metal in the water further loosens scale by its blasting action. The work is thus prepared for the final acid dip.



THREE-MINUTE DIP in dilute acid removes the now soluble scale. The work is ready for a rinse or hosing to wash off the acid. Result: a chemically clean surface—no pitting, etching or metal loss. TOTAL TIME—15 MINUTES.

SEND FOR THESE BULLETINS

—Get the whole story on Virgo Descaling Salt and Virgo Molten Cleaner—what they are, how they work, their advantages, how they fit your operations, and the Hooker services you enjoy as a user of the process. Send for these bulletins today.



1-1443

From the Salt of the Earth

HOOKER ELECTROCHEMICAL COMPANY

30 FORTY-SEVENTH ST., NIAGARA FALLS, N. Y.

NEW YORK, N. Y.

LOS ANGELES, CALIF.

TACOMA, WASH.

CHICAGO, ILL.

VIRGO DESCALING SALT—Producers and fabricators of stainless and alloy steels use Virgo Descaling Salt to quickly, positively remove scale produced by hot rolling, forging, extruding, casting, annealing.

VIRGO MOLTEN CLEANER—quickly, positively desands and degraphitizes castings; removes grease, dirt, chemicals, paint, enamel, rubber, atmospheric corrosion and other impurities.

This process can be used on steel; castings; forgings; fabricated parts; material to be salvaged. It employs simple equipment, and is easily adapted to your production methods.

Hooker Electrochemical Company

30 FORTY-SEVENTH ST., NIAGARA FALLS, N. Y.

Please send me Bulletins checked: Virgo Descaling Salt ☐
Virgo Molten Cleaner ☐

Name

Title

Company

Address

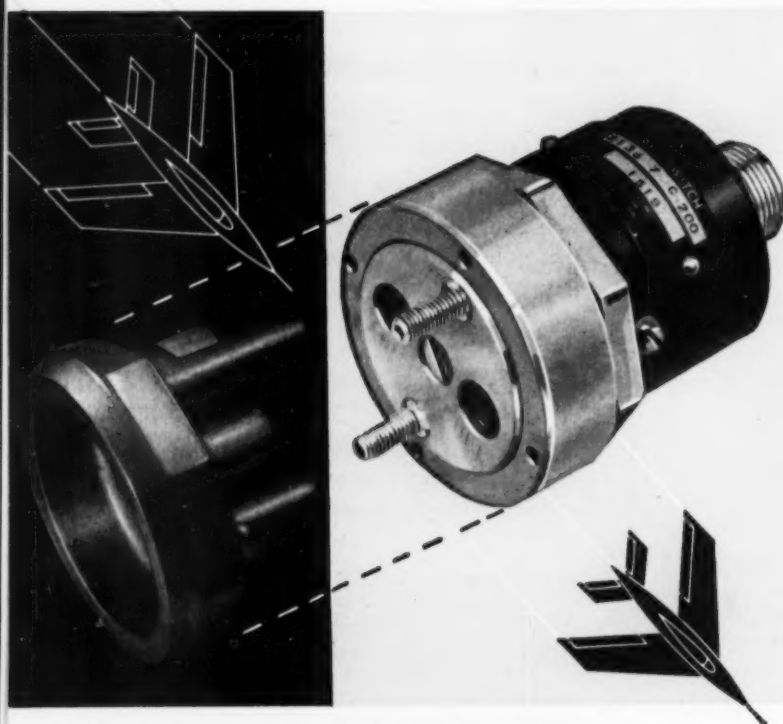
City Zone State



MUELLER BRASS CO. forgings help insure dependable operation of aircraft pressure warning instruments

A specially designed housing, accurately forged to customer specifications by Mueller Brass Co., seals in the diaphragm of the pressure warning unit manufactured by Eclipse-Pioneer Division of Bendix Aviation Corporation in Teterboro, New Jersey. The unit, designed for installation in fuel, oil, water or alcohol lines of modern aircraft is a highly sensitive instrument that instantly warns the pilot or flight engineer of any unusually high or low fluid pressures.

All Mueller Brass Co. forgings have a dense, close-grained structure with a high tensile strength. Weight savings up to 40% are possible in the design of parts because of the close tolerances to which they can be produced. Less scrap and longer tool life result from the easy machinability of forged parts. Mueller Brass Co. is completely equipped to design parts for your products, specify alloys (including special alloys developed by our metallurgists), forge, machine, finish and plate the parts and perform all necessary assembly operations. Write today for our free illustrated 32-page forgings catalog and complete information about MBCo forged parts for your products.



MUELLER BRASS CO.

PORT HURON 20, MICHIGAN

Iron Ore . . .

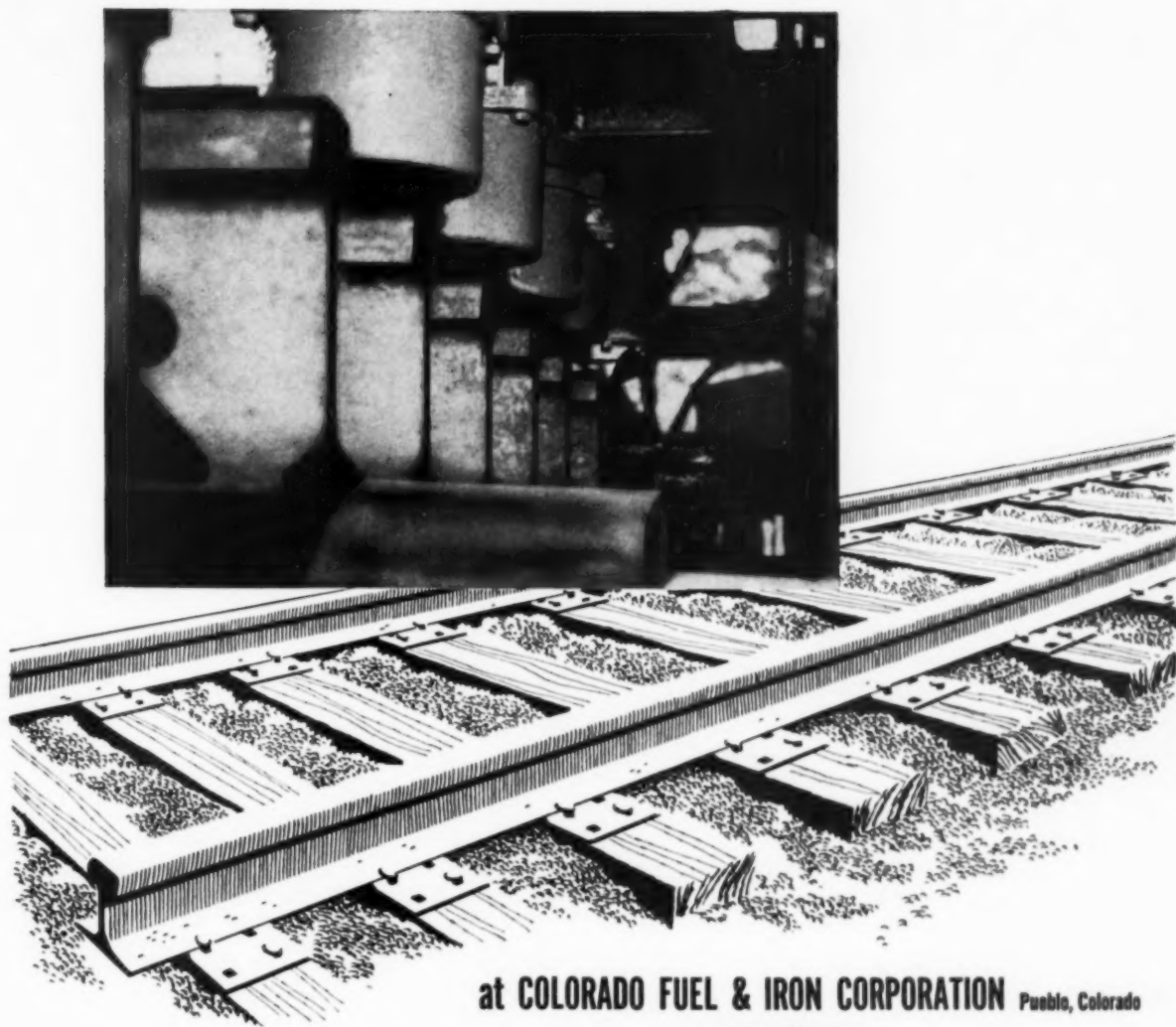
ents and the fritting of the ore particles together in a solid mass.

The experimental work involved sintering a sample of high-grade magnetite ore with varying mixtures of coke, flue dust (containing 15% carbon), and lime (CaO) in amounts from 0 to 5%; sintering a high-grade hematite ore (from Sierra Leone) with 6% coke, 30% sinter fines and 6% water; finally, sinters obtained from low-grade British ores (Northants and Fordingham) were studied after various degrees of heating. Samples of these products were then examined by radiographic methods to determine the structure of the sintered material (about 18 pictures of the various structures are shown and discussed in the paper).

Photomicrographs of the sinter obtained from the high-grade magnetite ore (Grangesburg) show an increasing disintegration of the original Fe_3O_4 ore particles as the percentage of carbon in the mix is raised from 2 to 5%. Sintors having the highest carbon content contained many tiny Fe_3O_4 crystals, formed during cooling, with a large amount of vitreous high-iron silicate slag; the 2% carbon sinters contained the original Fe_3O_4 grains of the unsintered ore. The high-coke sinters are hard and dense with low porosity while the 2% coke sinters are highly porous but have poor strength. The authors conclude that for this high-grade magnetite ore a mixture of 3% coke, 10 to 20% flue dust and 80 to 85% raw ore would produce the best structure after sintering. The addition of 2 to 5% lime to the Grangesburg ore mixes, together with 4% coke and 20% return sinter fines seemed to be beneficial. In every instance, crystals of monocalcium ferrite were found in the fused slag formed around the original ore fragments. These crystals apparently formed during cooling.

Sinters from a very fine hematite ore of high iron content (Sierra Leone) obtained from mixtures of 64% ore concentrates, (hematite of high iron content and of fine particle size), 30% return fines and 6% coke gave a different structure than those observed for the magnetite ores. A 4% addition of lime was also made to this mixture in one of the tests.

(Continued on p. 160)



at COLORADO FUEL & IRON CORPORATION Pueblo, Colorado

high speed processing with **GAS** produces longer lasting rails

The essential role of GAS as a production-line tool is particularly well demonstrated in the manufacture of railroad rails at Colorado Fuel and Iron Corporation, Pueblo, Colorado.

This process involves the use of GAS-fired radiant burners, with automatic cycle-timing devices, to harden the ends of the finished rails as they move out of the mill.

First the rails are pre-heated by GAS to 1000° F. Then the ends are heated by high intensity GAS radiants which automatically bring the temperature to 1600° in 95 seconds. Finally, a cold air blast

quenches and hardens the ends. This hardened area covers the entire rail width to a minimum depth of $\frac{1}{4}$ " and extends back from the end about $1\frac{1}{2}$ ".

High-speed heat processing with GAS results in longer rail life, lower maintenance costs, and greater safety for the railroads. The installation is one of thousands of *precision-tool* applications of GAS for exacting metallurgical requirements. If you would like further information on how GAS and Modern Gas Equipment increase efficiency, reduce costs, and improve products throughout industry, call your Gas Company Representative.

AMERICAN GAS ASSOCIATION

420 LEXINGTON AVENUE, NEW YORK 17, NEW YORK

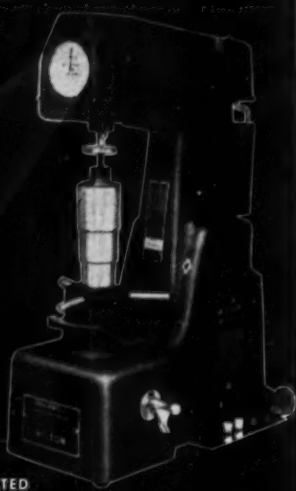


Wilson "Rockwell"* Hardness Testers

New Motorized
WILSON "ROCKWELL"*
Hardness Tester with
SET-O-MATIC* Gauge



Y MODEL
MOTOR-OPERATED



SET-O-MATIC* DIAL GAUGE

Eliminates human error. Operator merely applies minor load and taps depressor bar. No setting of dial to zero.

OTHER FEATURES

- Major load applied under dash pot control
- Major load removed by motor
- Illuminated Dial Gauge
- Illuminated Penetrator

Eliminates Operations... Increases Tests per Hour

All you have to do with the Model Y WILSON "ROCKWELL" Motorized Hardness Tester is apply the minor load and tap the major load depressor bar. The machine does everything else automatically. The cycle of Major Load operation may be less than 2 seconds.

This speed of test means great savings in time which will reduce your hardness testing costs. Yet it is done to Wilson's high standard of accuracy.

The utter simplicity of setting the SET-O-MATIC* dial gauge eliminates human error. The operator does not have to set the dial. The large pointer is automatically brought to "SET" position when the minor load is applied.

The Model Y Motorized WILSON "ROCKWELL" Hardness Tester is in production and orders are being accepted for early delivery. Write today for descriptive literature and prices.

*Trade Marks



Wilson Mechanical Instrument Division
AMERICAN CHAIN & CABLE

230-F Park Avenue, New York 17, N. Y.



Iron Ore...

The hematite is largely changed to magnetite during sintering and the lime addition does not cause the formation of calcium ferrite (as in the magnetite mix) but appears as a calcium-iron silicate slag. This result may be due to the large amount of free silica in the gangue of the hematite ore. No pictures of these hematitic sinters are reproduced in the paper.

The sinters made from low-grade British ores such as Northants or Fordingham are even more complex due to the wide variation in the type of iron minerals. These low-grade ores contain several iron-bearing constituents in widely varying proportions such as iron carbonates, ferrous aluminosilicates, and several forms of hydrated ferric oxide. In addition, the gangue contains CaCO_3 , clays, phosphates and gypsum. Free silica is almost entirely absent. The sintering of such material with different coke and lime additions leads to a very confusing series of structures and the making of a sinter of uniform quality from such low-grade ores is difficult on account of its continually varying chemical and physical properties.

The author reaches the following tentative conclusions as a result of this work:

1. The addition of lime to sinter mixtures which contain no free silica will prevent the formation of fayalite and other iron silicates.

2. If the sinter mix contains free silica, a lime addition will cause formation of calcium-iron silicate.

3. Lime additions promote the formation of the calcium ferrites and suppress the formation of the iron silicates.

4. Fuel content of the mix must be closely controlled and should be kept at a minimum that will produce a proper bonding slag.

It is obvious that each type of iron ore will present a different problem in any sintering operation, and that the chemical, mineralogical, and physical characteristics of both the iron-bearing constituents and the gangue, are important factors. Much more work needs to be done on the sintering of any type of ore with varying amounts of lime, carbon, and water in the raw feed to the sintering machine. E. C. WRIGHT

**machine that
almost thinks**

to and from
heating
furnace

to and from
hammer
or press

Of all the many production machinery and furnace items that Salem-Brosius supplies to the ferrous and non-ferrous metals industry, none has more versatility than the intriguing and exclusive Auto-Floor Forging Manipulator. The machine almost thinks. It reaches into a furnace, pulls out a forging billet, turns on its own axis, moves swiftly and independently to hammer or press. To satisfy any forging action, it raises and lowers, tilts, rotates and moves the billet from side to side. It disposes of the piece by either recharging it into a furnace or carrying it to the next operation. Employment of this remarkable manipulator results in one of the world's most economical heavy forging operations, because it replaces so much stationary handling equipment. Write for Salem-Brosius' new Manipulator Catalog today!

SALEM-BROSIOUS, INC.

EXECUTIVE OFFICES: 248 FOURTH AVENUE, PITTSBURGH 22, PA.

GENERAL OFFICES: 714 SOUTH BROADWAY, SALEM, OHIO



Controlled Quenching

**WILL BRING OUT THIS CHARGE
UNIFORM IN QUALITY**

The quenching stage of your heat-treating process is the point where all previous operations are brought to either a successful or unsatisfactory conclusion.

At this point is determined the final quality of your product...the amount of time and material wasted by sub-standard rejects...and *your ultimate operating cost!*

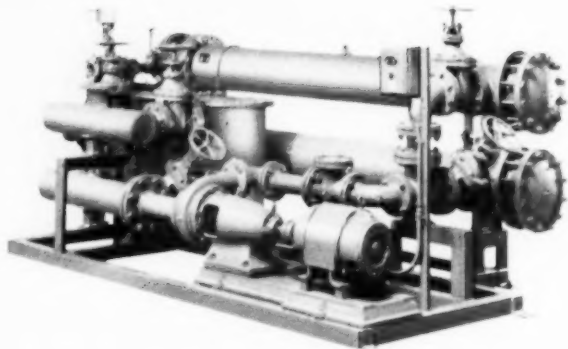
When you install a B & G *Hydro-Flo* Oil Quenching System you eliminate the warping and quality variations caused by uncontrolled quenching of heat-treated metal.

Oil is circulated at high velocity and with strong turbulence through the quench tank - then cooled and pumped back again. The oil in the quench bath is kept constantly at whatever temperature is desired. Since every batch is quenched under *identical conditions*, every batch is *identical in quality*.

While the individual components of an oil cooling installation can be purchased and assembled on the job, the trend today is to install completely factory-assembled oil cooling systems.

To meet this demand, B & G offers completely self-contained oil cooling units - integrated in every respect - ready for immediate operation. These units are engineered to your specific requirements.

Whether your heat treating volume is large or small, the services of the B & G engineering department are available. Your request for information will receive prompt attention.



The B & G Self-Contained Oil Cooler illustrated here is pre-engineered and assembled complete at the factory. It eliminates the need for building pump piers and stands and for assembling pipe, valves, controls and wiring. Your only responsibility is to place the unit in position and connect it to the quench tank and water lines. It can be easily moved if a change in plant arrangement makes it necessary.



Hydro-Flo OIL QUENCHING SYSTEMS

BELL & GOSSETT COMPANY

Dept. DO-16, Morton Grove, Ill.

Canadian Licensee: S. A. Armstrong, Ltd., 1400 O'Connor Drive, Toronto

*Reg. U. S. Pat. Off.

*if you
need
stainless
wire —
call
CRUCIBLE
for quick
delivery*



For any diameter from the smallest to half an inch or more . . . in any temper from dead soft to full hard . . . with a bright surface, or with one of many metallic or nonmetallic finishes — yes, for *any* stainless steel wire, call Crucible.

Crucible's modern stainless steel wire mill is the last word in up-to-date production facilities. What's more, this is combined with the very finest metallurgical and quality control setup you can find anywhere. It means, for you, that every coil . . . every length . . . *every inch* of Crucible stainless steel wire

can be produced to the most rigid standards of quality — that Crucible stainless wire conforms to precise standards of uniformity that are unsurpassed in the industry.

So, whatever your requirements for stainless wire — cold heading . . . free machining . . . spring . . . rope . . . weaving . . . armature binding . . . slide forming — Crucible's fine new mill is ready to serve you promptly with wire products of the very highest quality. Call your nearest Crucible warehouse for prompt delivery.



CRUCIBLE

first name in special purpose steels

54 years of *Fine* steelmaking

STAINLESS STEEL WIRE

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.
REX HIGH SPEED • TOOL • REZISTAL STAINLESS • MAX-EL • ALLOY • SPECIAL PURPOSE STEELS

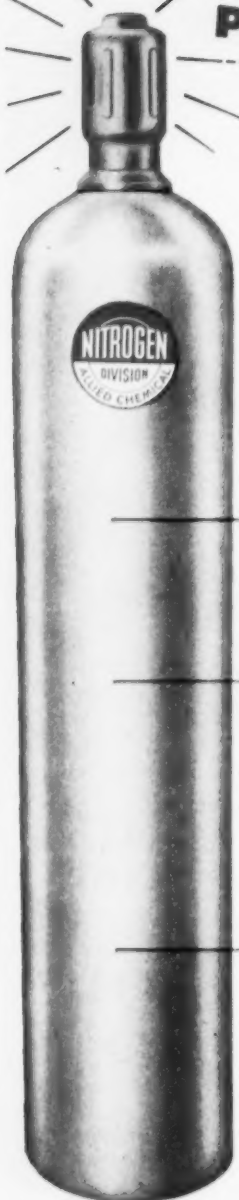
Canadian Distributor — Railway & Power Engineering Corp., Ltd.

PUSH PRODUCTION UP
PUSH COSTS DOWN

with

BARRETT®
 BRAND

Anhydrous Ammonia FOR METAL TREATING



Here's Why in a Nutshell: You get 6750 cubic feet of mixed hydrogen and nitrogen when a single 150-pound cylinder of Barrett Brand Anhydrous Ammonia is disassociated at normal temperature and pressure. One of the most economical sources of disassociated hydrogen and nitrogen for metallurgical uses!

Economical For These Important Uses!

- Protective atmosphere for bright annealing, brazing and powder metallurgy.
- Nitriding of alloy steels and carbonitriding (Dry Cyaniding) for treatment of steel.
- Case hardening of iron and steel with case depths up to 0.025 inches.
- Sintering of metal powder compacts.
- Augmenting corrosion-resistance treating for aluminum, magnesium, other light metals.
- As a solvent in making electrolytes for electrolytic recovery of salts.

Fast Delivery. Barrett Brand Anhydrous Ammonia is stocked coast-to-coast in 150-, 100- and 50-lb. cylinders. An adequate supply of cylinders in all sizes helps assure fast delivery in the size you want. If you use large quantities, ask about our tank truck delivery service—you'll save money.

FREE Technical Help. Technicians specially trained in the use of Anhydrous Ammonia for metal treating will help you. No obligation. Also, valuable handbook, "Guide to Use of Barrett Ammonia in Cylinders" shows most economical usage; contains chemical properties, handling, charts, etc.

FREE! Ammonia Leak Detector Safety Kit! Pocket-size, this new handy kit quickly detects ammonia leaks. May be used over and over. Write today!



NITROGEN DIVISION

ALLIED CHEMICAL & DYE CORPORATION
 40 Rector Street, New York 6, N. Y.

Review of Problems in Resistance Welding Coated Steels*

LITERATURE on the resistance welding of coated sheet steel is lacking in fundamental data on metallurgical aspects, being confined principally to analyses of production difficulties. Furthermore, most available information deals with spot and seam welding, with little reported on projection or flash welding of coated materials.

Nonmetallic coatings, because of their high electrical resistance, are entirely unsuited to resistance welding. Welds made in sheet steel carrying phosphate, oxide or paint coatings are of poor quality, irregular in character, resulting in quick deterioration of electrodes and impaired corrosion resistance of the coating.

In respect to cadmium-plated steel, a combination of high electrode pressure (15,000 psi.), high welding currents and short weld times appears to meet general acceptance. Electrodes of chromium-copper alloy show best resistance to deformation under high pressure, and exhibit little coating pick-up after as many as 200 to 500 welds, given adequate cooling.

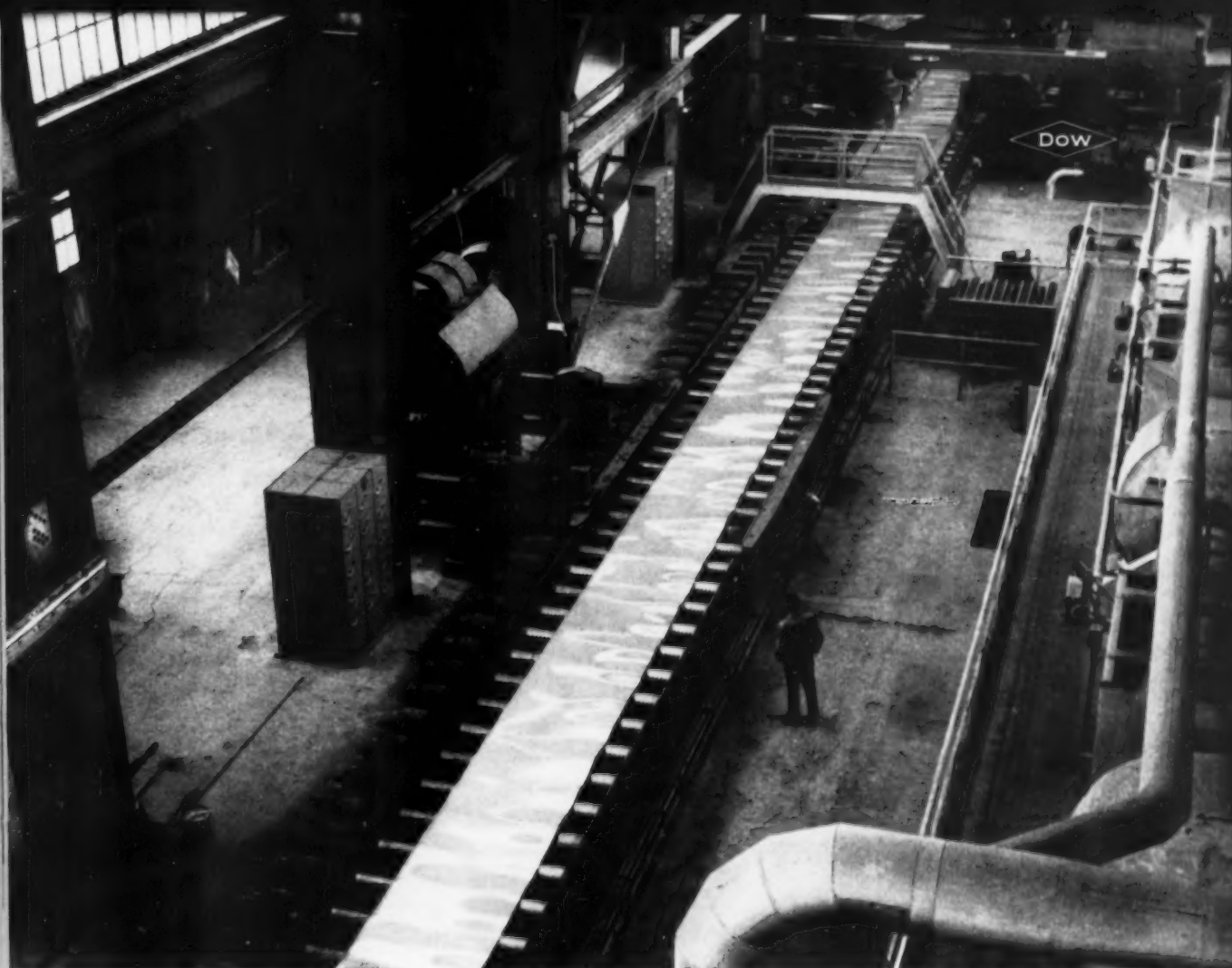
Low melting point of lead andterne plate coatings suggests a longer hold time and the likelihood of considerable electrode pick-up, requiring frequent cleaning. Effective seam welding of such coatings calls for higher than normal wheel loads and currents, although somewhat lower wheel speeds, with perhaps continuous cleaning of wheels.

Sheet steel plated with tin or tin alloy, in the consensus of investigators, is best welded with tip pressures around 15,000 psi. Electrode pick-up is less with tin-zinc alloys than with pure tin. This is minimized by high currents at short time intervals and efficient cooling.

Precleaning of aluminum-clad steel is advisable, either by scratch brushing and pickling or by simple degreasing and brushing. Again, high currents, short time and high

(Continued on p. 164)

*Digest of "Resistance Welding of Coated Steels", by J. E. Roberts, *British Welding Journal*, Vol. 1, May 1954, p. 233-237.



World's First 84" Magnesium Coil Mill.

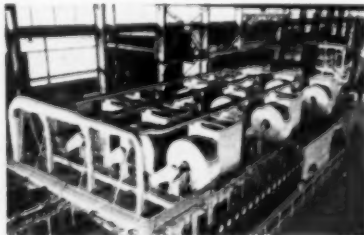
a new look at Magnesium!

**UP TO 25%
PRICE REDUCTION
ON SHEET AND PLATE**

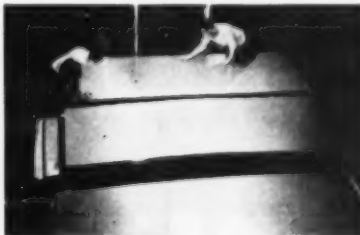
New Dow facilities—now in operation—are producing magnesium sheet in quantity. Wider, longer—magnesium sheet now offers a brand new challenge to designers, engineers, manufacturers. To cut costs, to save weight, to add strength—to do revolutionary new things for many products—get the new magnesium story! Call the nearest Dow sales office or write THE DOW CHEMICAL COMPANY, Magnesium Department, Midland, Michigan.



Here for the first time, large magnesium rolling ingots weighing nearly a ton are being rolled.



Specially designed, carefully controlled ovens pre-heat huge magnesium ingots just before rolling.



Constant inspection plus rigid production controls assure uniform magnesium sheet quality.



Note how coil of magnesium sheet illustrates new availability in greater widths and lengths.

you can depend on DOW MAGNESIUM

DOW

Resistance Welding ...

tip loads are generally recommended.

Three types of zinc coatings—galvanized, sherardized and electro-deposited—are amenable to spot welding. The more consistent thickness of electrocoated material is productive of more uniform welds. Tests with electrodes cooled by refrigerant have shown a reduction in metal pick-up and better electrode life, but the cost of the cooling installation

appears to outweigh the advantages it offers.

Failures have been encountered in seam welding of zinc-coated steel components, probably resulting from work hardening or strain aging of the base material. The condition may be aggravated by either the welding process alone or by zinc penetration of the strained metal during welding.

Metal pick-up usually will be encountered to greater or lesser degree in spot and seam welding of all types of coated steel. Palliatives

such as refrigeration of electrodes or modifying the welding technique by the use of slope control of current, are not justified costwise. The best procedure is to accept whatever pick-up develops, provide an adequate supply of replacement electrodes and clean those which have become contaminated.

A. H. ALLEN

Internal Stresses in Forgings Minimized With Slow Cooling*

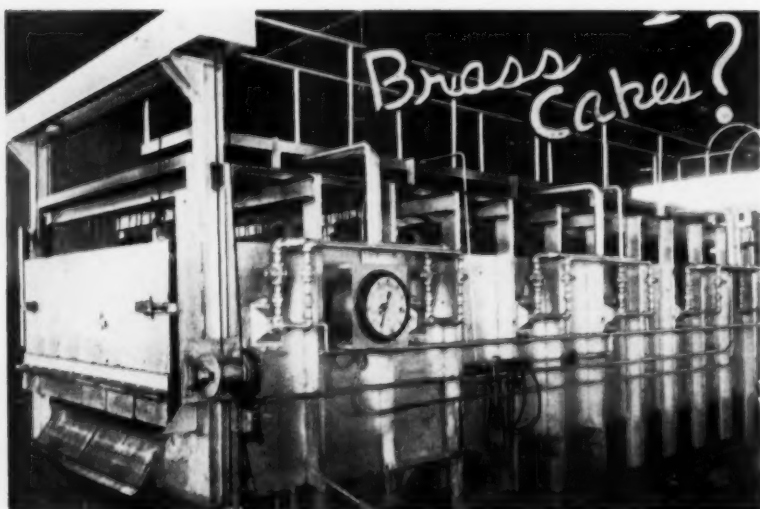
LARGE forgings often receive heat treatment which results in significant residual stress. This stress, of itself or in combination with service loads, may be of sufficient magnitude to cause failure. A knowledge of the causes of internal stress and of the means of minimizing it is, therefore, of considerable interest.

If the study is limited to cylinders, if simplifying assumptions are made, and if the physical constants of the material over the required temperature range are available, certain helpful equations can be written. Among these are: (a) the relation of stress during cooling to temperature difference between center and surface; (b) the relation of stress during cooling to the same temperature difference expressed in terms of surface cooling rate and diameter; (c) the relation of residual stress after tempering to the creep strength at the tempering temperature; and (d) the relation, during air cooling, of surface cooling rate to diameter for any surface temperature.

Both (a) and (b) assume elastic conditions with no relaxation due to plastic readjustment. Stress is shown to be directly proportional to temperature difference so that cooling rate is influential only as it affects this difference. The ratio of cooling rate to temperature differences varies considerably with temperature level, that required to produce the same difference and thus the

(Continued on p. 168)

*Digest of "Internal Stresses in Some Types of Forgings", by C. Sykes, a lecture given before the North East Coast Institution of Engineers and Shipbuilders in Newcastle-Upon-Tyne on Oct. 30, 1953, and subsequently published in the Institution's *Transactions*, Vol. 70.



Copper
Aluminum

BILLETS, SHEETS, TUBES,
COILS, RODS OR CAKES

JET specially designed furnaces for nonferrous metals heats them all more economically.

JET annealing furnaces or high temperature heaters, direct or radiant fired are built with close controlled atmosphere.

JET furnaces give you extra profit by automaton devices which keep production high and reduce man hours.

JET furnaces are engineered to use the cheapest fuel available to you.

JET furnaces always carry a comparatively low initial cost—

It's a good bet to see **JET**

JET combustion, inc.
INDUSTRIAL FURNACES • EQUIPMENT ENGINEERS
7917 South Exchange Avenue Chicago 17, Illinois

Mt. Vernon Die Casting Corp., says...

*"We highly
Recommend"...*

AJAX

TAMA-WYATT
Induction Furnaces



Two views of AJAX furnaces installed at the new Stamford, Conn. plant of Mt. Vernon Die Casting Corp. Photo at left shows two 165 kW furnaces in foreground for melting aluminum, and in background two 50 kW and two 25 kW furnaces for melting zinc. The zinc die casting machines are shown in right rear.

Upper photo shows another view of the 165 kW furnaces, with control cabinets in the background.

After a most satisfactory experience of more than five years with AJAX low frequency induction Furnaces in their Mt. Vernon, New York plant, this company has now installed the furnaces shown above in their new modern plant at Stamford, Conn. "We are convinced," they state, "that economy of operation makes this type of furnace well worth while. We intend to continue to install them till all our die casting machines are fed by AJAX furnaces."

All ALUMINUM alloy at Mount Vernon is melted in a central group of AJAX melting furnaces. Small individual AJAX holding furnaces serve many ALUMINUM die casting machines.

All ZINC die casting alloy is prepared from pure metals in another group of AJAX melting furnaces. AJAX holding furnaces serving all ZINC die casting machines are supplied through an AJAX-engineered molten ZINC distribution system requiring no labor.

Years of practical experience with AJAX induction equipment enabled Mount Vernon Die Casting Corporation to take full advantage of this up-to-date method of melting in their new plant. The result is outstanding production efficiency and quality control.

We at AJAX Engineering are proud to have played a part in this achievement.

Write for Reprint of Article Giving Further Details on This Installation

AJAX

TAMA-WYATT



AJAX ENGINEERING CORP., TRENTON 7, N.J.

INDUCTION MELTING FURNACE

AJAX ELECTRO-METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Bortherup High Frequency Induction Furnaces
AJAX ELECTRIC CO., INC., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

Plenty of Copper..

today and tomorrow

✱ The assurance that copper is in abundant supply and *can be used without restrictions* is the "go ahead" for industry. You can now rate **PERFORMANCE** over **AVAILABILITY** when choosing materials. By using copper and its alloys, brass and bronze, your product is easier to fabricate, better and more durable.

We can get more copper than we now have. Although industry and government have been consuming more copper than in any previous peacetime period, production has kept pace with this increased demand. And producers are not working at full capacity!

More copper keeps on coming. Eleven major new projects in the U. S. will start producing in the next 3 years. These mines will add 250,000 tons to our annual production—more than $\frac{1}{4}$ of all the domestic copper mined during 1953. In addition, recent improvements in mining techniques now make it possible to obtain copper from ores considered commercially unworkable in the past.

Copper is virtually indestructible. At least 3 out of every 4 pounds of copper used in today's products, when scrapped, can be re-used in the future. Every day we are adding to our "copper capital". The more copper we use . . . the more we have!

SHORT
TONS

1,500,000

1,400,000

Copper or its alloys provide these advantages . . .



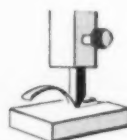
Best conductor of electricity commercially available.



Does not rust . . . high corrosion resistance.



Best heat transfer agent of all commercial metals.



Easy to machine, form, draw, stamp, polish, plate, etc.



Welds readily . . . excellent for soldering and brazing.



Source—American Bureau of Metal Statistics Year Book 1953

Copper has a new ability to serve you. Many of your problems are being solved in the laboratories of the copper and brass industry. Whether it's a new alloy, a different temper or a special property . . . copper can help you develop new ideas. Copper can bring old methods up to date. Call a supplier of copper and brass and convert your thoughts to action!

COPPER & BRASS

Research Association



* "Copper . . . is fortunately available in ample supply to meet any foreseeable demand"

Foreword, U. S. Dept. of Commerce
B.D.S.A. Copper Quarterly, August 1954

For information about U. S. copper supplies including free copies of this Government report and the new booklet, "Copper . . . Today and Tomorrow", send attached coupon to:

Copper & Brass Research Assn., Dpt. P
420 Lexington Ave., New York 17, N. Y.

NAME
COMPANY
ADDRESS
CITY STATE

Internal Stresses ...

same stress being three times as great at room temperature as at 1110° F. The stress caused by thermal gradients may be very high. In a cylinder a nominal stress of about 22,400 psi. results from a difference of 144° F. from outside to center.

In carbon or low-alloy forgings the high nominal stress indicated by the above does not persist undiminished beyond 660° F. because at higher temperatures the material becomes less capable of supporting high stress elastically. If no relaxation occurred there would be, in the absence of allotropic transformation, no resid-

DIAMETER, IN.	COOLING RATE IN °F. PER HR., FOR A RESIDUAL STRESS OF		
	4500 PSI.	11,200 PSI.	22,400 PSI.
10	74	185	370
20	18	45	90
40	4.5	11	22
80	1.1	2.8	5.6

ual stress after cooling uniformly to room temperature. Usually, however, almost complete relaxation does occur and with it a high residual stress. This stress is opposite to that which caused relaxation. Thus, in a cylinder the center is in compression during cooling but in tension once it has cooled throughout to room temperature. The accompanying tabulation, which assumes

the presence of no transformation stress, shows that rather slow rates of cooling are necessary at 1110° F. if a low residual stress is desired in large rounds.

A nominal stress of 4500 psi. is considered reasonable for a final stress-relieving operation; 11,200 psi. is satisfactory for a forging cooled for rough machining prior to final stress relieving; 22,400 psi. might be deemed safe for ingots which are to be reheated for forging.

Insofar as residual stress is concerned, the natural cooling rates obtained in a furnace or in air are opposite to what we desire for greatest economy of cooling time. Uniform cooling at a uniform rate is inefficient because it does not take advantage of the fact that for the same residual stress the cooling rate at each temperature decrement should be accelerated. The cooling rate may be increased by an amount which causes an additional stress equal to half the "Hatfield time yield" at the corresponding temperature without significantly increasing relaxation. Hatfield time yield is defined as the stress which produces an average extension of 10⁻⁶ in. per in. per hr. over the period of the creep curve from 24 to 72 hr.

A program of cooling can be calculated on this basis to utilize a gradually increasing cooling rate down to the temperature at which the work may be removed from the furnace. Such a cycle may reduce the furnace time by one half and still be safer than conventional furnace cooling to room temperature. Below 660° F. normalized carbon steel will carry elastically a stress of 22,400 psi., and a cooling rate sufficient to cause this stress will not add to the residual stress. Because the surface cooling rate of rounds of any diameter at any temperature can be computed easily and accurately, and since stress may be determined from cooling rate, we can confidently select the temperature for removing the work from the furnace.

When phase changes are involved,
(Continued on p. 170)

MAKE ACCURATE TESTS ANYWHERE!

WITH
Ames
PORTABLE
HARDNESS TESTERS



Ames Portable Tester making hardness test on large casting while being machined.

You can get accurate, dependable tests anywhere, anytime, with Ames Portable Hardness Testers. No delays, no waiting for laboratory tests, no cutting off specimens. Anyone can operate.

Ames Testers are light in weight — may be taken to the work — read directly in the Rockwell Scales. Are made in sizes from 1" to 8" capacity for testing rounds, flats, sheet stock, tubing, odd shaped pieces and assembled parts.

Look into this time-saving, inexpensive method of making your hardness tests today. Thousands in every day use. Send for folder "Rockwell Hardness Testing Made Easy".

ARRANGE FOR A DEMONSTRATION WITH THE FOLLOWING DISTRIBUTORS

ANN ARBOR, MICHIGAN

Eberbach & Son, Co.
200 E. Liberty Street

EVANSTON, ILLINOIS

Adolph I. Buehler
2120 Greenwood Ave.

PHILADELPHIA, PA.

Donovan Company
1415 North 2nd Street

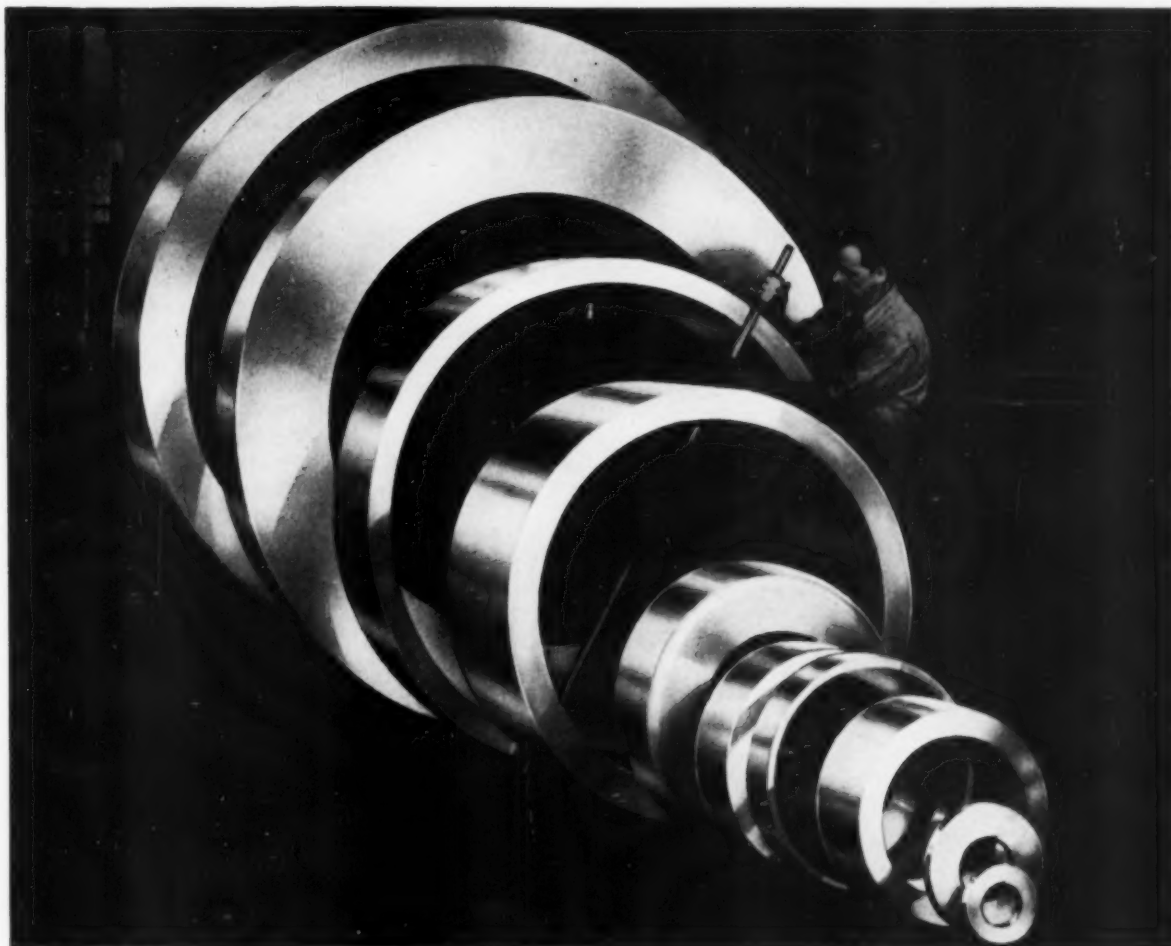
NEW YORK, N. Y.

Testing Machines, Inc.
123 West 64th Street

AMES PRECISION MACHINE WORKS

Makers of Ames Precision Lathes and Bench Millers

WALTHAM 54, MASSACHUSETTS



***A Ring OF Extra Service* IN EVERY ONE**

Rings for turbine reduction gears . . . thrust rings for bearing raceways . . . die rings for mills . . . Midvale craftsmen make them all. From the smallest ones of a few inches in diameter to one hundred eighty-five inches, from twenty pounds to twenty thousand pounds they are quality-controlled in every step.

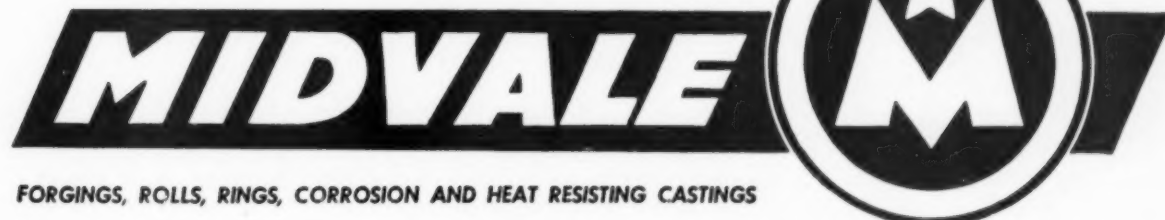
Each Midvale ring is exact in metallurgical specifications because of the experienced steel making practices and complete open hearth and electric furnace facilities of Midvale. Rings are carefully shaped by craftsmen with years of forging and rolling skill. Heat

treated in temperature controlled furnaces to assure wearing qualities that will withstand the severest friction, abrasive, crushing and grinding action.

This is why Midvale rings are noted for their long life . . . why gear makers order Midvale blanks . . . why Midvale rings and roll shells are used on the toughest installations. The men of Midvale working with the right equipment and facilities offer you a source of rings, rolls and forgings unsurpassed in quality and extra performance.

THE MIDVALE COMPANY-Nicetown, Philadelphia 40, Pa.

Offices: New York, Chicago, Pittsburgh, Washington, Cleveland, San Francisco



FORGINGS, ROLLS, RINGS, CORROSION AND HEAT RESISTING CASTINGS

Internal Stresses . . .

a knowledge of the isothermal transformation characteristics of the material is necessary for an analysis of the problem. When transformation occurs at 1110° F. or above, very substantial relief of the accompanying stress occurs as it proceeds. If it occurs at 660° F. or below, substantial residual stress remains. The problem is complicated in large rounds by transformation that does not take place isothermally, the heat

evolved during transformation, and the difficulty of accurately determining the center temperature. Means are available of calculating the cooling curve of transformation in large forgings which check observed results satisfactorily.

Few large forgings are shipped today simply as normalized. There are, however, respected sources of information in the U.S. who would not consider it improper, for example, to ship carbon steel forgings over 24 in. diameter in the normalized and untempered condition so long as the carbon content did not

exceed 0.35%. The doubtful wisdom of such practice is demonstrated by actual measurements showing that the stress at the center of a normalized 32-in. round with 0.30% C was 36,000 psi., whereas it was 27,000 psi. at the center of a 27½-in. round having 0.39% carbon.

Whatever the stress may be that results from cooling with or without transformation, it can be very nearly eliminated if tempering at a high temperature is permissible provided, of course, that the tempering is followed by a sufficiently slow cool to hold the residual stress below the permissible maximum. If the tempering temperature is such that the Hatfield time yield is no greater than 2200 psi., the unrelieved stress after a 10-hr. hold will not exceed 2500 psi. Since carbon and many low-alloy steels have a Hatfield time yield of about 2200 psi. at 1110° F., the normal tempering of large forgings reduces the stress to an acceptable level.

The simplifying assumptions which are made to facilitate stress analysis in cylinders during cooling are generally shown by experimental data to err on the safe side. Ingots up to 85 in. diameter have been faced smooth on each end prior to trepanning, and measurement of the shrinkage of the trepanned core relative to the remainder has provided ample evidence of the safety of the assumptions.

Thermal stress analysis of many items is far more complicated than that of solid rounds, but considerable work has been done on familiar shapes. For example, stress distribution in hardened hollow cylinders has been measured by Sachs's boring-out method and has been calculated from physical constants and temperature distribution by Treppschuh. An analysis of the stress in disks also has been made by calculation and by measurement.

In the foregoing, heat treatment has been discussed purely as it affects residual stress. It is recognized that additional criteria may have to be considered such as temper brittleness, flakes, and others.

It is hoped from this discussion that engineers will be more fully aware of the problems involved and will appreciate the attention which is being devoted to the production of reliable forgings.

M. W. ACKER

New Black Magic

plus

Magic Mist

gives a Wear Resistant, Low Friction, Solid Lubrication coating to all parts subjected to wear.

For Example:

It has been reported that an ordinary carbon tap treated by this process was equal or better in performance to a chromium plated high speed tool tap which cost three times as much.

Manufacturers have been reporting 20 to 500% increase in the life of drills and reamers when treated with Magic Mist.

Case histories prove better lubrication qualities and longer life for all machinery parts processed with Black Magic plus Magic Mist.

This is an economical dip process that is designed to do production work in a matter of minutes. The added wear resistance, low friction and solid metallic lubrication obtained is a must for all manufacturers of moving parts.

If it moves—it needs Black Magic and Magic Mist.

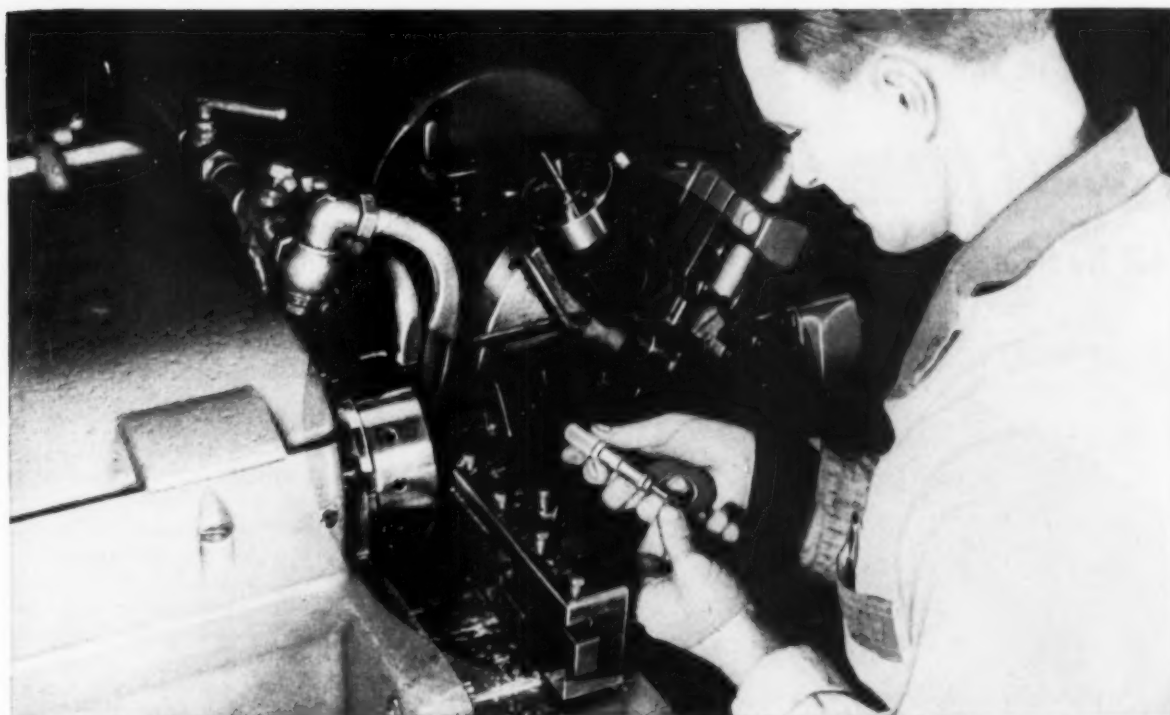
**LET US FINISH YOUR PARTS SO THAT
You Can Test and Evaluate this Process**

Mitchell-Bradford

The MITCHELL-BRADFORD CHEMICAL CO.

243 Main St. Stratford, Conn.

QUALITY PRODUCTS OF CHEMICAL RESEARCH



TOOL LIFE INCREASED 40% USING CITIES SERVICE CUTTING OIL



ONE OIL FOR ALL? After poor results with many cutting oils, the Dunbar Machine & Tool Company discovered all their cutting jobs could be done to perfection using only one oil . . . Cities Service Chillo #44.



NO EYE STRAIN. In addition to a 40% increase in tool life, owner Robert Dunbar found that the transparent characteristics of Chillo #44 help eliminate eye strain. Cutting operation is easily visible to operator.

Production Also Up, Reports Dunbar Machine & Tool Co.

THE PROBLEM . . . The Dunbar Machine & Tool Company had a problem. It seemed impossible to find one oil which would perform economically and efficiently for ALL the jobs required of the firm's automatic screw machines.

THE SOLUTION . . . After trying many brands of cutting oil, "none of which gave good all-round performance," owner Robert Dunbar called in a Cities Service engineer. After careful analysis of the problem, the engineer recommended Chillo #44 cutting oil.

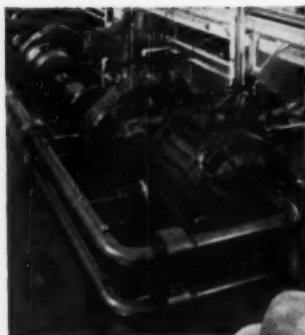
THE RESULTS . . . Using Chillo #44, the company observed these results: Tool life increased nearly 40% . . . Production increased accordingly . . . Additional savings realized due to chip draining characteristics of oil . . . Holding tolerances no longer any problem . . . Machine clean-up time now insignificant . . . Transparency of oil eliminates eye-strain . . . Less smoke and fumes at high speeds . . . Also excellent for lubricating purposes. Says Mr. Dunbar, "Our results with Chillo #44 permit us to heartily endorse this product."

If you have a cutting oil problem, consult your nearest Cities Service representative or write Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

in the
World's Largest
oil hydraulic pumps

Upper: Waterbury Size 300 pump under test. Lower: Lebanon casting, machined ready for fabrication.



LEBANON STEEL **Castings**
are at work...

IN WATERBURY TOOL'S SIZE 300 PUMPS—largest oil hydraulic high-pressure pumps ever built—dependable Lebanon CIRCLE L castings help confine the tremendous forces developed. These pumps are the working heart of the world's largest tube reducing machine being built by E. W. Bliss Company for Tube Reducing Corporation. On the tube reducer these pumps will move the equivalent of three fully loaded freight cars three feet forward and three feet backward—every two seconds! Each pump weighs 21½ tons, is capable of delivering 2300 gallons per minute at pressures up to 3000 p.s.i. and can transmit up to 4000 H.P.

Lebanon steel castings in the pumps for this extraordinary machine that cold rolls tubing up to 18" O.D., were engineered and built for enduring service.

See—STEEL WITH A THOUSAND QUALITIES—37-min., 16 mm, semi-technical, full-color, sound film on the making of steel castings. For information write: Dept. II, Lebanon Steel Foundry.

LEBANON **Castings**
CARBON, SPECIAL ALLOY
AND STAINLESS STEEL



**Character of Oxide
Scales on Titanium***

A FURTHER step has been taken in the investigation of the products formed by the oxidation of titanium by pure oxygen between 1110 and 1700° F. at 700 mm. of mercury. The titanium strip was prepared from arc-melted titanium ingots by hot swaging and rolling operations performed in air at 1110° F. Scale was removed by a wire brush followed by immersion in 10% solution of nitric-hydrofluoric acids. The specimens of commercial titanium measured 1.75 x 1.5 x 0.2 cm., and those of the refined metal 1 x 0.5 x 0.1 cm. The specimens were suitably annealed and then treated so that the surface had an excellent polish, free from pitting, and was slightly etched to permit measurements for grain size.

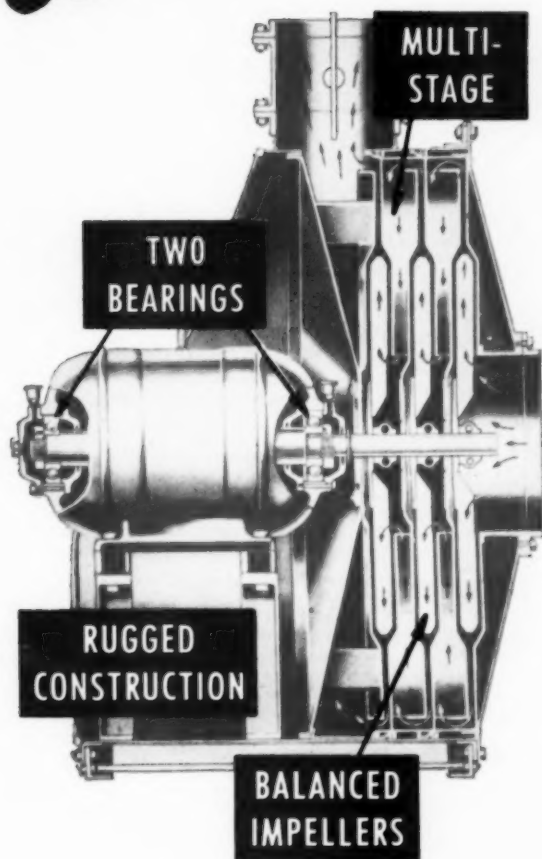
The test consisted of placing specimens in a platinum-lined, glazed porcelain boat. Oxygen was supplied at 700 mm. pressure and suitable temperature control was provided. Glancing angle X-ray-diffraction technique was used to determine the structure of the oxidation products. It was found that in one respect titanium was unique in that the oxygen absorbed is distributed between a scale and a metal core. In the latter case the absorption was confined to the outer layers.

It was possible to remove the scales (which had a rutile chemical structure) as complete sheets from the underlying cores and so examine each separately. The refined titanium had thicker scales which protected the cores. At 1832° F. the scales heated in vacuum were absorbed by the cores. The presence of oxygen in the titanium lattice could be detected by an increase in hardness. At the low temperatures the scale is thin, dense, and slate-gray in color; at the higher temperatures the scale is thick, porous, and yellow-brown in color. Basic experimental research such as is described in this paper is of inestimable value in connection with the application of titanium to jet engine uses. H. J. ROAST

*Digest of "The Oxidation of Titanium at High Temperatures in an Atmosphere of Pure Oxygen", by A. E. Jenkins, *Journal of the Institute of Metals*, Vol. 82, January 1954, p. 213-221.

CONTINUOUS PRODUCTION

Assured 4 Ways WITH SPENCER TURBO-COMPRESSORS



There are good reasons why the annual installation of Spencer Turbos has increased tenfold in ten years and why a recent analysis shows that repair parts amount to less than one dollar per machine per year.

No. 1. The Spencer multi-stage construction allows a smaller diameter machine with lower peripheral speeds of the fan blades and of the motor itself. The wear on the bearings is therefore cut to a minimum.

No. 2. The only rotating contacts are at the two ball bearings, which if kept greased will assure satisfactory operation without work stoppages for many years.

No. 3. Here is a machine as simple as an electric fan, with a rugged construction, as sturdy as a steel bridge and with wide clearances between the rotating elements and stationary parts. Users say "the Spencer goes on forever with little attention."

No. 4. Balanced Impellers. Each fan is individually balanced before the machine is assembled. This decreases the vibration, increases the life of the bearings and packing and produces quiet performance.

35 TO 20,000 C.F.M.; 4 OZ. TO 10 LBS.; 1/3 TO 1,000 H.P.

440 H

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONNECTICUT

SPENCER
HARTFORD

Scope of Application for Subzero Treatments*

IN ASSEMBLING metal parts, either by the expansion-fit or expansion-and-shrink-fit processes combined, the use of subzero temperatures is often advantageous. When certain steel and most aluminum alloy parts are assembled, damage caused by the necessarily high temperatures of shrink-fitting can be eliminated by subcooling the internal part. This expansion-fit process either reduces

*Digest of "Subzero Treatment of Metals", by H. T. Gregg, Jr., *General Electric Review*, July 1954, p. 19-21.

heating of the external part to a point where it causes no damage or eliminates it altogether, and may also replace hydraulic press equipment. A press-fit assembly that previously required tons of pressure can now be made by hand, thereby lowering manufacturing costs, increasing production, and avoiding strains being set up and scoring of mating surfaces. Some subzero applications include assembling cast alloy valve-seat rings in automobile cylinder blocks, placing an alloy steel ring around coining or cold forging dies to prevent splitting, assembling case hardened ring gears without tempering the case, inserting steel ball-bearing races in a cast iron

housing, and assembling thousands of bearings and bushings of all sizes and shapes. Certain assembled parts, such as large bushings, may also be removed, if a tightly fitting cup-type container of subzero-cooled convection fluid is inserted.

Probably the most important application of subzero temperatures is delaying age hardening of aluminum rivets. Heat treated rivets of 17 S and 24 S aluminum alloy are stored at -40 to -50°F ., immediately after quenching, and age hardening action is suspended for several weeks, in contrast to the two-day delay at 32°F . Thin sections and intricate parts made of 17 S and 24 S alloys, prone to become distorted if heat treated after forming, may be heat treated after blanking and stored at subzero temperatures until ready for forming.

Machine tool efficiency is increased by using a coolant because the heat generated at the cutting edge of the tool is a big factor in lowering wear resistance. Temperatures of 1100 to 1200°F ., often attained at the cutting edge of high speed steel cutters, weld chip to tool as well as soften the cutting edge. Use of a coolant — even compressed air — passed through a refrigerated coil at subzero temperatures will reduce these temperatures and lengthen the tool life. Toolsteel cutters having low "red hardness", such as tungsten finishing steel, can be run under a subzero air coolant at higher speeds than normal without danger of losing hardness.

Precision parts can be stabilized in a matter of hours with subzero treatments. Machine tool castings no longer have to be subjected to outdoor weather conditions for several seasons and the U. S. Bureau of Standards has long since changed its requirement that certain gages be naturally aged for 6 years. An example where a high degree of stability is required is a set of plug gages worn undersize on one end and increased in size on the opposite end. Subjected to -160°F . for 5 to 15 hr., several of the gages increased in size from 0.0005 to 0.0008 in. per in. of diameter. Also, Rockwell C hardness increased two to three points. These gages were pre-World War I, aged for more than 30 years at room temperature. For most requirements for high hardness and dimensional stability, a series of

(Continued on p. 176)



**MONEY-SAVING TIPS
ON SYLVANIA
TUNGSTEN ELECTRODES
AND INERT GAS
WELDING TECHNIQUES**

**ASK YOUR
SYLVANIA DISTRIBUTOR
FOR THIS GREATEST OF**

Time-Saving Welding Charts

No more guesswork about inert gas welding! Here's a helpful, new chart based on research by Rensselaer Polytechnic Institute. Gives you valuable facts and short cuts . . . helps you save time, material, and money.

EASY-TO-READ TIPS. This folder lists tough welding problems and gives solutions side by side. Tells what to do about difficult starting, brittle electrode tips, contamination, excess heat . . . and many other problems.

Ask your Sylvania Welding Distributor for a couple of these FREE charts. Also check your supply of Sylvania packaged electrodes . . . Thoriated Tungsten, Puretung, and Zirtung . . . the rods tested for quality and uniformity from ore to finished products. For any further information write: Dept. 4T-2309, Sylvania TODAY!

**FINGER TIP
SOLUTIONS TO YOUR
TOUGHEST PROBLEMS!**

Speeds work,
Avoids trouble, Saves dollars!

SYLVANIA

Sylvania Electric Products Inc., 1740 Broadway, New York 19, N. Y.

LIGHTING • RADIO • ELECTRONICS • TELEVISION

In Canada: Sylvania Electric (Canada) Ltd., University Tower Building, St. Catherine Street, Montreal, P. Q.

Enthone **AT WORK** Protecting Zinc, Cadmium, Copper, Brass, Steel



ENTHONE CORROSION PREVENTIVES

Stand up to Salt Spray

At Enthone our sole aims are the development of better methods for the improvement of metal finishing and the reduction of finishing costs. These we have accomplished in the field of corrosion prevention. Our research chemists and engineers are responsible for the following outstanding metal finishing products for the prevention of costly corrosion:—

ENTHOX: Puts iridescent, gold-colored chromate coating on zinc and cadmium. An excellent base for organic finishes. Highly resistant to corrosion; withstands salt spray from 100 to over 1000 hours.

COMPOUND 39: A one-operation phosphating and cleaning compound for steel and zinc. Fine grained, highly adherent phosphate coat is ideal base for organic finishes. Gives high bond strength.

EBONOL "C": Gives jet black cupric oxide coating to copper and its alloys. Chemically stable; heat stable; very adherent. Fine base for organic finishes. Readily withstands salt spray.

COMPOUND NR-31: A rustproofing agent for iron and steel. Leaves thin surface film that prevents rusting when drying water off metal or when storing parts in water. Quickly removed by rinsing in water.

COMPOUND NR-37: An organic rust-inhibitive compound that prevents rusting while evaporating water from

steel or iron following hot or cold rinsing. The compound evaporates as the water evaporates, leaving the surface ready for organic coating.

COMPOUND NR-40: A neutral degreasing and rustproofing compound for iron and steel. Imparts light, corrosive-resistant film. Cleans, temporarily rustproofs in one operation. Excellent for hot water drying of steel.

RUSTPROOFING OIL NO. 15: A polar solvent-type rustproofing oil that leaves thin film on metal. Safety solvent with flash point well over 100°F. Completely sheds water. Has a salt spray resistance of 15 to 24 hours.

RUSTPROOFING SOLUBLE OIL: An emulsifiable, rustproofing material. Corrosion-resisting oil film is created by diluting oil with water. Protects steel against rust for 10 to 15 hours in salt spray.

ENTHONE Chemical Products are formulated to meet specific metal finishing needs. Consult any one of our field representatives or write our research department regarding your finishing problems. They will gladly tell you about the ENTHONE products designed to fit into your production picture—offering operational savings, improved product performance and increased production efficiency. Write today for an obligation-free consultation.

**The Scientific Solution of Metal Finishing Problems.*



METAL FINISHING PROCESSES

442 ELM STREET, NEW HAVEN, CONNECTICUT

ELECTROPLATING CHEMICALS

Service Representatives and Stock Points: BINGHAMTON, N. Y., Austin F. Fletcher, Inc.; CHICAGO, Ardeo, Inc.; CLEVELAND, R. O. Hull & Co.; DALLAS, Weaver Engineering & Supply Co., Inc.; LOS ANGELES, L. H. Butcher Co.

Subzero Treatments...

treatments at about -150°F . is adequate. Gage blocks, cooled from room temperature to -120°F . five or six times during the final finishing operation, have been stabilized to within 0.000002 in. A low-temperature draw — low enough to maintain a hardness of Rockwell C-65 in the block — usually follows each subzero cycle.

The use of subzero treatments as a supplement to heat treating is one of its more recent applications. The percentage of untransformed

austenite in cooled or quenched steel can be reduced considerably if quenching is done at subzero temperatures. As cooling reaches approximately -120°F ., only a negligible amount of untransformed austenite remains. The increased volume and hardness resulting from this conversion of austenite into martensite means that an improperly heat treated tool or die that has shrunk when quenched can often be salvaged by subzero treatment. If ball-bearing steels, such as the S.A.E. 52100 are treated at -150°F . after the first temper, hardness will be increased by several points.

While there is little doubt as to the usefulness of very low temperatures in such processes as assembling, controlling age hardening, and machining, its usefulness in the heat treatment of steel is still disputable. The use of subzero temperatures in metallurgical operations is largely unexplored, but it is believed that the availability of practical low-temperature refrigeration will expand its use.

C. T. FINLEY

Commercial Feasibility of Titanium Castings*

AN ATTEMPT was made to answer some of the questions which have been raised regarding the commercial feasibility of titanium castings. These questions are:

1. Does a noncontaminating mold material exist?
2. Can titanium castings be made which are nonporous, free of surface defects, and dimensionally accurate?
3. Can chemically homogeneous titanium alloy castings be made?
4. Will cast titanium have as good mechanical properties as wrought titanium?

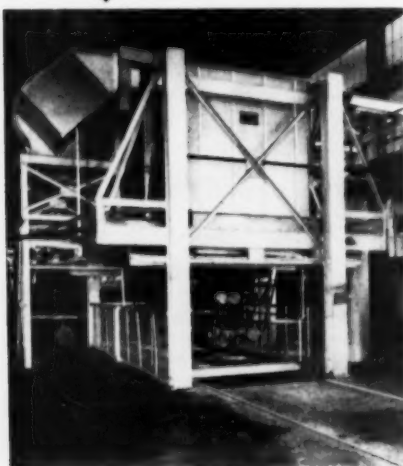
All castings prepared for this study were made in a skull-melting furnace under an argon atmosphere. In skull melting, the center of the charge is melted with an electric arc while a thick layer, or skull, of unmelted metal is left between the melt and the crucible. This method of melting minimizes contamination from the crucible.

Mold refractories were evaluated by pouring 2-oz. heats of titanium into small refractory molds and measuring the hardness of the resulting castings. Hardness measurements indicated whether or not the castings were contaminated. Castings made in molds of silica, zircon, zirconia, beryllia, thoria, magnesia, alumina, and titanium carbide were all contaminated and were all considerably harder than the titanium charge. Those made in carbon and graphite molds had the same hardness as the titanium charge.

(Continued on p. 178)

*Digest of "Preliminary Survey of Some Metallurgical Bases for a Titanium Castings Industry", by R. F. Malone, H. T. Clark, S. V. Arnold and W. L. Finlay, presented at the American Foundrymen's Society Convention, Chicago, May 5, 1953.

YOUNG BROTHERS OVENS



1st

in dependable
Low Cost
**HEAT
TREATING**

Rapid Quench Heat Treating Oven

Young Brothers Ovens are engineered and built by oven specialists to meet individual heat treating problems. That's why it will pay you to consult with Young Brothers Co. first for your particular oven requirements.

You can be sure of improved production and savings in time and material regardless of your process, when you install Young Brothers Ovens.

Experience gained in over 50 years of developing Batch and Conveyor Ovens for thousands of installations is your assurance of outstanding performance and competent service. For consistently better results, get the information on Young Brothers Ovens first.

Write for Bulletin 14-T.



Established 1896

YOUNG BROTHERS COMPANY

1829 Columbus Road

Cleveland 13, Ohio



BRIDGEPORT ALUMINUM

is backed by 89 years of Superior Customer Service

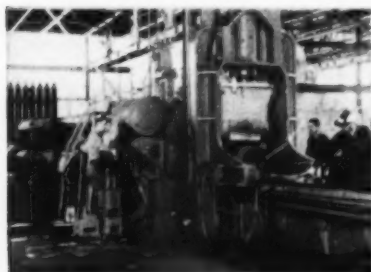
Personalized service to customers has always been an important part of Bridgeport's policy. That's why, when you discuss your aluminum requirements with a Bridgeport representative, you'll find him paying careful attention to matters like your fabricating, production and finishing problems, cost factors and your

finished product . . . in short, a good deal more than just the order.

This customer service is backed by a staff of trained light-metal production specialists, which assures you of quality Bridgeport Aluminum Products—and *on-time* deliveries.

Other specialized Bridgeport

services are available to you in the form of research and technical assistance—development work in titanium and magnesium—all yours to use in solving your light-metal problems. Call your local Bridgeport Sales Office for more information on Bridgeport Aluminum Products and our services.



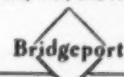
Bridgeport's sixteen extrusion presses with capacities from 1650 tons to 5500 tons can serve your needs for Aluminum Extrusions in a wide variety of shapes and alloys.



Bridgeport Contour Hand Forgings save production and material costs on high-strength parts in limited quantities. Write for your copy of this Forging Folder.

BRIDGEPORT BRASS COMPANY

ALUMINUM DIVISION • BRIDGEPORT 2, CONN.
Sales Offices in Principal Cities—Conveniently
Located Warehouses
Mills at Bridgeport, Conn.,
Indianapolis, Ind., and Adrian, Mich.



See our exhibit at the
National Aircraft Show
September 4, 5, 6, Dayton, Ohio

BRIDGEPORT ALUMINUM

SAVE OUTSIDE CHARGES

Owning a Waltz furnace eliminates outside heat-treating charges. Assuming your furnace operating costs to be the same as those of the outside service, your savings can equal the profit of the outside service.



here's what you save

WITH YOUR OWN WALTZ HEAT-TREATING DEPARTMENT

SAVE MATERIALS-HANDLING

You save paper work and shipping costs by heat-treating on the premises. All high-speed steels can be processed in your Waltz plant, which heat-treats, quenches, draws, stress-relieves, normalizes and anneals.

SAVE PRODUCTION DELAYS

No work gets held up waiting for outside service when you have your own Waltz equipment standing by in a corner no bigger than a utility kitchen. These always-ready facilities give you the speed and convenience you need for emergencies.



Write today
for comprehensive
bulletin describing all features
and specifications.
Dept. W

Waltz

FURNACE COMPANY
SYMMES STREET • CINCINNATI, OHIO

Titanium Castings...

Carbon molds chilled the casting less severely than graphite molds and permitted sharper reproduction of corners on the casting. Because carbon and graphite were quite promising mold materials, they were used to prepare titanium castings for further tests.

To obtain castings free of cold shuts and splashes, it was necessary to preheat graphite molds to 1470° F. and gate the castings from the bottom. Cylindrical castings weighing 15 to 24 lb. were made by this procedure. When poured under a reduced pressure of argon, a porous subsurface rim surrounded the castings. This porosity was reduced by casting at atmospheric pressure. Shrinkage in the castings ranged from 0.020 in. per in. for sections 2 in. thick, to 0.0126 in. per in. for sections 11½ in. thick.

Chemical analyses of samples taken from several areas in a cast cylinder of unalloyed titanium showed that there was very little carbon or nitrogen contamination from the graphite mold. The carbon content of this casting was 0.03 to 0.04% and the nitrogen content was 0.02 to 0.03%. Titanium sponge from which the casting was prepared contained 0.02% C and 0.02% N.

A titanium alloy casting with 4% Al and 4% Mn weighing 24 lb. was analyzed for homogeneity. Five samples taken from different portions of the casting all had about the same chemical analysis. From these results, it was concluded that skull melting could be used for making chemically homogeneous titanium castings.

The mechanical properties of an unalloyed titanium casting and an all-alpha alloy casting (7% Al) were comparable to those of similar wrought titanium alloys. Although the strength of an alpha-beta cast alloy (4 Al, 4 Mn) was greater than that of a similar wrought alloy, its ductility was much lower. Therefore, it appears that this alloy is not suitable for casting purposes.

Basically, titanium has good castability, and titanium castings are commercially feasible. However, it may be several years before all the technical problems involved in casting titanium are solved.

R. M. LANG



SPECIALISTS ***at Your SERVICE...***

**with the Only Organization
Exclusively Devoted to
Rolled Heat Resistant Alloys**



PAUL GOETCHEUS
President



ROLLO BORING
Vice President



FRED LATTIN
Chicago



AL WILSON
Cleveland - Pittsburgh



JOHN MAXSON
Philadelphia



ANSON ALBREE
New England



LLOYD BOHAN
Los Angeles



BILL BAIER
Detroit

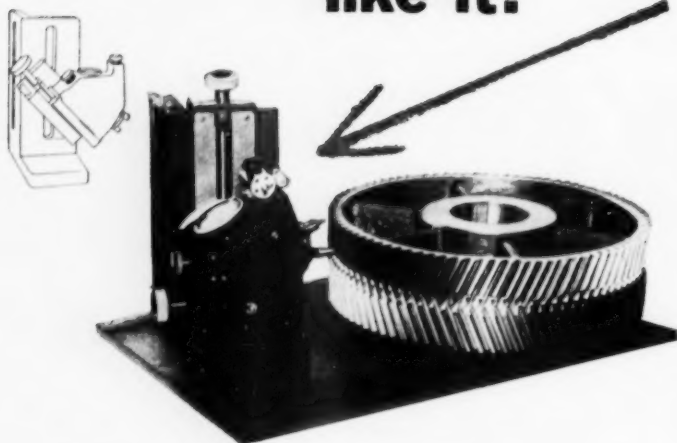
Rolled Alloys, Inc., now provides six strategically located service centers manned by qualified metals engineers. These alloy specialists are ready to render experienced help in the proper selection and application of rolled heat resistant alloys. If you need proven heat resisting alloys, call your nearest "Rolled Alloys" representative for quality metal, service and value. We carry in stock over 300 sizes of rolled alloy mill forms for immediate shipment, whether by pound or in tonnage quantities.

*Your requirements and inquiries will
receive our careful, interested attention.*

ROLLED ALLOYS, INC. 
Heat and Corrosion Resistant Alloy Specialists

4815 BELLEVUE AVENUE, DETROIT 7, MICHIGAN • TEL. WALNUT 1-4462

there's nothing
like it!



penetrascoper metal hardness tester

No clamps needed with this new, semi-portable Multiple-Angle Metal Hardness Tester. For a combination of accuracy and versatility, there is nothing like it in American industry today.

The Multiple-Angle Penetrascoper illustrated above was developed for testing the many parts and places inaccessible when clamps are used — gear teeth roots and large bearing races, for example. The Penetrascoper is movably mounted on a magnetic stand holding the unit firmly to a ferrous surface on which the object to be tested is also set securely. Adaptability is obtained by angling the stand on the ferrous surface, by angling the Penetrascoper on its stand, and by adjusting the height of the Penetrascoper on the stand.

For more accessible work, the basic Penetrascoper is available with a variety of C-Clamps and Magnetic Clamps. The Penetrascoper employs a 136° pyramidal diamond indenter and loads from 1 kg. to 30 kg. Extremely accurate results are obtained in the range 16 to 800/1000 D.P.H., with excellent comparative results up to 1500 D.P.H.

PENETRASCOPER "PLUS" VALUES

1. **Accurate** — Extremely accurate from 16 to 800/1000 D.P.H.
2. **Versatile** — Capable of conventional and multiple-angle testing of large or small pieces; pieces can be tested at site.
3. **Portable** — Basic unit weighs about 18 pounds net; extra weight of semi-portable multiple-angle unit is more than offset by its versatility.
4. **Minimum marring** — light loads permit minute impressions, considered by many to be non-destructive.

Send for our booklet on the Penetrascoper today.

C. TENNANT, SONS & CO., OF NEW YORK
100 PARK AVENUE, NEW YORK 17, N. Y., U. S. A.
TELEPHONE OREGON 9-1300

Welding, Metallurgy and Design in British Shipbuilding*

THE USE of welding in merchant shipbuilding in Great Britain has developed steadily without abrupt change-over from riveting as in the United States. Such rapid change-over has brought some unforeseen and distressing problems in world shipbuilding.

Notch-toughness at service temperatures in mild steel has been shown to be of great importance in avoidance of brittle failures. Consequently, the shipbuilding industry collaborated with steelmakers and metallurgists in an intensified research program. Much has been learned, but much is yet unknown. Early attention was directed to chemical composition and it was found that in ship plate used during the war, carbon content was high and manganese content unusually low. This was corrected with a higher manganese-to-carbon ratio. Structure of the steel was then studied and these studies revealed that notch-ductility decreased with plate thickness. Strain aging was also shown to be of importance. For special quality steel, in addition to increasing the manganese-to-carbon ratio to obtain high notch-ductility at low temperatures, it is necessary to use aluminum-killed steel and to give it a normalizing treatment.

Much work has been done with laboratory tests and their correlation to service failures. Two types of tests are in use in the United Kingdom, both of which use plate specimens. Work has been done on the interpretation of surface markings associated with brittle failure. From these studies it has been found that the process of propagation of brittle failure in a plate consists in the formation of successive disk-shaped cracks originating ahead of the main fracture front. The Admiralty Ship Welding Committee has given much attention to the choice of the most suitable test for assessing notch-toughness. They believe that a single

(Continued on p. 182)

*Digest of "Aspects of Welding Research in British Merchant Shipbuilding", by R. B. Shephard, *Welding Journal*, Vol. 33, January 1954, p. 23-40.



What a 26 TON DIE BLOCK means to you!

Actually weighing 52,980 pounds with dimensions 25" x 48" x 156", the die block shown above was one of eight which were made for forging aircraft parts. All of the dies are still producing close dimensional forgings.

What does that mean to you? It means that you can place absolute confidence in the workmanship and materials that go into any Finkl product whether large or small. To make a die block or forging of this size and quality requires the utmost skill and knowledge of steel and its characteristics. This is apparent in every phase of the operation from our own electric steel furnaces through forging, heat treating, machining and inspection.

For 75 years Finkl has been proving that the best is the least costly in the long run by manufacturing only the finest in forgings and die blocks. Call one of the offices listed below the next time you are considering die blocks or forgings. There is no obligation and should you choose Finkl, you will choose the best.

Write for this free catalog telling all about Finkl die blocks and forgings, the types of steel, the proper selection for the job, how to make dies last longer, and many other helpful facts. Please send request on your company's letterhead.



DETROIT 26: 2838 Book Bldg, Woodward 1-1315 • CLEVELAND 14: 1914 NBC Bldg, CHerry 1-2939
 • PITTSBURGH 22: 762 Gateway Center, ATLantic 1-6391 • INDIANAPOLIS 5: 132 East 30th Street,
 Hickory 4647 • HOUSTON 1: P.O. Box 1891, CApital 2121 • ALLENTOWN: 737 North 22nd Street,
 HEmlock 4-3333 • ST. PAUL 1: 445 Endicott Bldg, CApital 2-1600 • COLORADO SPRINGS: 534 West
 Cheyenne Road, MEIrose 2-0431 • SAN FRANCISCO 5: Monadnock Bldg, EXbrook 2-7018 • SEATTLE 4:
 3104 Smith Tower, SENece 5393 • BIRMINGHAM: P.O. Box 1606, 7-1603 • KANSAS CITY 6: 950 Diercks
 Bldg, HARrison 1060 • Western warehouse LOS ANGELES 29: 1001 N. Vermont Avenue, NOrmandy
 3-2141 • Eastern warehouse EAST CAMBRIDGE 41, MASS: 250 Bent Street, ELliot 4-7650

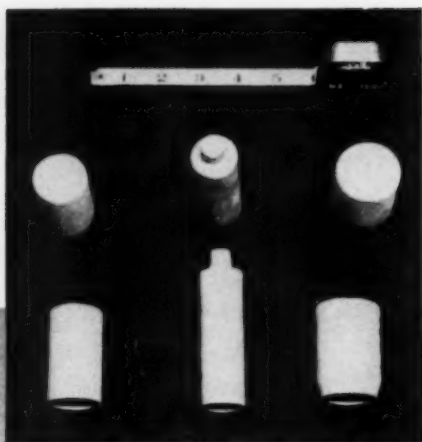
A. Finkl & Sons Co.

2011 SOUTHPORT AVENUE • CHICAGO 14

FORGINGS • DIE BLOCKS • ELECTRIC FURNACE STEELS

Small

HIGH ALLOY
CASTINGS

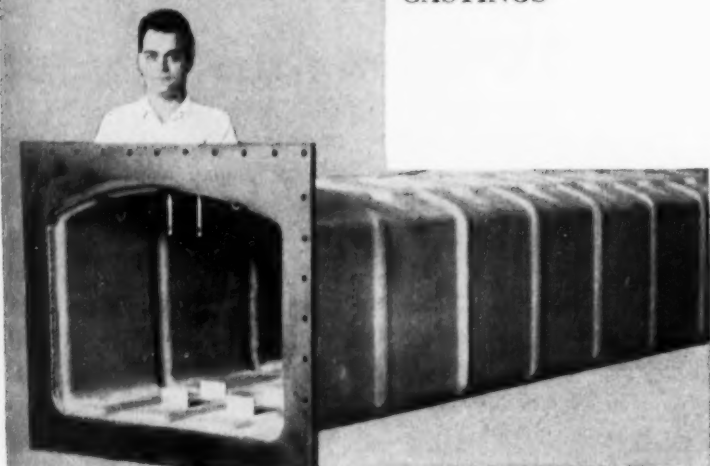


Carburizing Fixture for Ball Bearings 1½" diameter—Analysis 35% Ni—15% Cr

DURALOY

Large

HIGH ALLOY
CASTINGS



Muffle for Continuous Strip Annealing 12' 6" long—Analysis 38% Ni—18% Cr.

LARGE or small **DURALOY**, can do it! These are just typical examples of the work moving through our foundry. Some of these castings are designed for heat resistance, some for corrosion resistance, some for abrasion resistance; all are cast by experienced foundrymen. All are carefully tested in our up-to-date laboratory.

If you have a high alloy casting problem . . . **LARGE** or small, we can help you. For more information, send for Bulletin No. 3150-G.

THE DURALOY COMPANY

Office and Plant: Scottsdale, Pa. • Eastern Office: 12 East 41st Street, New York 17, N.Y.

Detroit Office: 2795 Woodward Avenue • Pleasant Ridge, Mich.

Atlanta: J. M. TULL

Chicago: F. O. NELSON

Metal & Supply Co.

121 S. Michigan Avenue

METAL GOODS CORP. Dallas • Denver • Houston • Kansas City • New Orleans • St. Louis • Tulsa

British Ships . . .

standard test is preferable and have recommended the general adoption of the Charpy V-notch impact test.

Fundamental research has also been carried out. This includes work on pure iron and pure iron alloys performed by the National Physical Laboratory. The rules of Lloyd's Register were amended in 1949 to provide for certain ratios of manganese and carbon contents in quality ship plate over ½ in. thick. For structural parts exceeding 1 in. thick it is required that properties and processes of manufacturers of the steel are to be specially approved for the purpose. Steelmakers are invited to submit for approval steels which they can readily and consistently produce. They must furnish full details of manufacture. Notch-bar tests of samples are then carried out. From the available data the suitability of the material is determined. If the steel is considered satisfactory, approval for its use is granted on the understanding that substantially the same analyses and processes of manufacture will be maintained. Impact tests are made periodically. This is an approach quite different from that in the United States.

Studies of residual or locked-up stresses have demonstrated that such stresses probably cannot be controlled after welding. While under certain conditions the presence of residual stresses must be considered to reduce the load factor for elastic instability, they cannot be considered to affect the static capacity of a structure provided the material behaves in a plastic manner. It has been shown that where no notch is present high residual stresses of themselves cannot produce brittle failure. In the presence of a notch, residual stresses cannot be ignored in a material which is notch-brittle.

Great interest is being shown in aluminum alloys for use in shipbuilding, although high cost has restricted their use. Heat treatable and nonheat treatable alloys of the aluminum-magnesium and aluminum-magnesium-silicon types have been used and much research has been done to improve their weldability. Inert gas processes have been used.

Much work has been done on arc characteristics. The fundamental

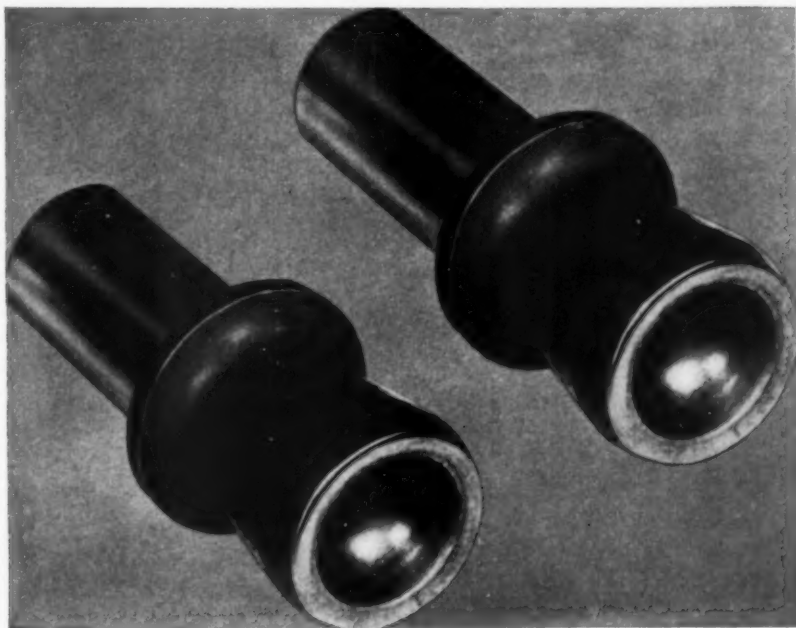
(Continued on p. 184)

Tool Steel Topics

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation, Export Distributor - Bethlehem Steel Export Corporation

BETHLEHEM
STEEL



Boiler Shop Using Bearcat Rivet-Sets Ups Average Run from 300 to 2470

The mechanical department of a large boiler shop had trouble driving more than 300 hot rivets, using standard rivet-sets. Once that mark had been reached, the sets would crack or spall. Sometimes recupping saved the day, but oftener than not the sets had to be replaced.

We were sure they could get longer runs with rivet-sets of Bearcat tool steel. The management gave Bearcat a trial, and put six sets to work after a heat-treatment cycle consisting of preheating at 1200F, air-quenching at 1750, and tempering at 550.

The results were even better than expected. The average run increased from 300 to 2470 before recupping was required. Not only that, but the recupping was accomplished without heat-treatment, which of course is a frequent source of trouble with rivet-sets of carbon tool steel.

Bearcat is an ideal tool steel for the manufacture of rivet-sets because of its superior shock-resistance. It is also well suited for uses where hot-work properties and easy machining are essential.

—BEARCAT'S BIG FEATURES—

1. Super shock-resistance
2. Deep-hardening . . . in air
3. Machines easily (Brinell 197 max)
4. Low distortion in heat-treatment
5. Good hot-work properties
6. Easily carburized for long wear

Typical Analysis

C	Mn	Si	Cr	Mo
0.50	0.70	0.25	3.25	1.40

In addition to being used for rivet-sets, Bearcat is ideal for such hot- and cold-shock applications as chisels, punches, hot headers and gripper dies. It has many other uses, too — master hobs, engraving dies, die-casting dies, and short-run dies used in cold-forming, blanking and bending.

You'll be well pleased with the service life obtained with Bearcat. We stock Bearcat in our mill depot. Or you can obtain a supply through your local Bethlehem tool steel distributor.

BETHLEHEM TOOL STEEL ENGINEER SAYS:



Use Care When Hardening Hot-Work Tools

Although hot-work tools can be hardened to Rockwell C-56-60, there are hardly any applications where such hardness is beneficial. The majority of hot-work tools are used in a hardness range of C-41-44, or C-46-49. On new hot-work applications, a common mistake is to heat-treat to a hardness level which is too high for the application, with the result that rapid heat checking or breakage occurs.

For example, put tools of our Hot Work 8 analysis to work at C-55 or higher, and chances are, they will fail prematurely. Yet these same tools, used at Rockwell C-52 or lower, will give outstanding service.

On every hot-work application the best hardness level must be determined by experience. There's always a compromise involved, as the highest hardness is best for wear-resistance, and the lowest hardness is more resistant to heat-checks. Our suggestion? To be sure of maximum service, don't overharden hot-work tools.



IT'S A-H5 FOR LONG PRODUCTION RUNS

This high-production die, made of A-H5, blanks and punches sheet steel of 0.180-in. thickness. A-H5 makes possible long production runs between grinds. It holds a durable cutting edge, and resists distortion in heat-treatment.

Two New RCA ELECTRON MICROSCOPES

The EMU-3A and EML-1A

*Providing
Greater Magnification
and Resolution Than
Ever Before Possible*



With the development of these two revolutionary new instruments, an advanced field of research lies before you... new worlds to conquer!

- Consistently higher magnifications than ever before possible.
- High resolving power — 20 Angstrom units. (EMU-3A)
- Choice of 50,000 volt and 100,000 volt accelerating potential. (EMU-3A)
- Vertical column construction for stability and accessibility.
- Single set of pole pieces for all magnifications.

- Insensitive to vibration and magnetic fields.
- Roll film and plate cameras—choice of four different picture sizes.
- External control and adjustment of objective aperture.
- Binocular viewer.
- Large 5" x 5" direct view, high-brightness screen.
- Push-button controls—unusual ease of operation.
- Selected area and reflection diffraction.

Installation and service facilities of the RCA Service Company available.

Send for information on these great new RCA Electron Microscopes. Write to Dept. I-104, Building 15-1, Radio Corporation of America, Camden, N.J. In Canada: RCA VICTOR Company Ltd., Montreal



**RADIO CORPORATION
of AMERICA**

VISIT RCA AT THE INSTRUMENTS EXPOSITION, PHILA., SEPT. 15-21, BOOTHS 213-217

British Ships...

physics of heavy current, high-voltage arc discharge has provided useful basic knowledge on the welding arc. This has been of particular value in the study of the "Argonarc" welding process.

A series of full-scale structural tests on welded and riveted ships has been undertaken. The program is in two stages: (a) in still water and (b) under service conditions at sea. Certain classes of tankers and dry cargo ships practically identical in design and of both welded and riveted construction were available. Tests showed no significant difference between similar welded and riveted ships in the general stress distribution and deflection in the main hull girder. The results correspond to those predicted from conventional beam theory. No evidence was found of rivet slip nor of support for a commonly held belief that welded ships are stiffer. Extensive sea trials were performed to determine forces acting on the hull. The analysis of the resulting data, a lengthy and formidable task, has just been brought to completion.

During these full-scale ship tests, opportunity was taken to secure information on vibration, in order to develop new methods and to improve existing methods of calculating critical frequencies of ships' hulls. Among other results the tests showed that critical frequencies in both welded and riveted construction are closely in agreement. The welded ship, however, tended to have larger vibration amplitudes, suggesting that structural damping is greater in the riveted ship.

Many welded dry cargo ships have developed corrugations in the bottom plating between floors. The bottom plate of these ships is drawn in slightly during construction due to thermal contraction at the connecting fillet welds. This dishing, or unfairness, progresses in service under repeated compressive loading combined with hydrostatic pressure. This progressive unfairness is evidence of the increased compressive stresses in the bottom structure of the modern cargo ship.

In contrast to aircraft, there is little evidence that fatigue strength rep-

(Continued on p. 186)



LESS MACHINING BETTER DESIGN LOWER COST

HIGHER QUALITY MATERIAL

thanks to **ACCUMET PRECISION INVESTMENT CASTINGS**

This bolt-making machine transfer arm used to be machined from a forging of SAE 1045 steel. A grooved pin had to be machined and assembled in the forging, and many milling, broaching and drilling operations were needed to produce the finished part.

Then a Crucible ACCUMET® precision investment casting was tried, using heat-treated SAE 4140. Results? All machining except drilling and tapping two small holes was eliminated. Better functional design was achieved. A more rugged grade of steel was used. The manufacturer's machine tools were released for other jobs.

This is just one example of hundreds where ACCUMET precision investment castings have

improved the design, function and performance of a component part — *with a reduction in cost.* It was possible because Crucible — the country's leading specialty steel producer — has established standards of quality and uniformity in its ACCUMET precision castings that are unsurpassed in the industry.

So look over the machining operations in your shop. Take an *extra* long look at the intricate products that are made in many costly, high-reject steps. Then let your Crucible representative show you how ACCUMET precision investment castings can help you lower costs and improve your products.



CRUCIBLE

first name in special purpose steels

54 years of *Fine* steelmaking

ACCUMET INVESTMENT CASTINGS

CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.
 REX HIGH SPEED • TOOL • RESISTAL STAINLESS • MAX-EL • ALLOY • SPECIAL PURPOSE STEELS

Canadian Distributor — Railway & Power Engineering Corp., Ltd.



WHY POWDER METALLURGY?

... Because Powder Metallurgy is the speedy, lower cost method of producing small metal parts with blueprint accuracy.

Parts may be so pressed and sintered that costly machining is eliminated or simplified.

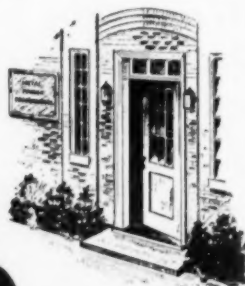
Parts can be produced to close tolerances. For economy, there's no wasted metal—since die overflow powder can be reused.

WHY MD METAL POWDERS?

... Because nearly forty years of research and manufacturing experience have made MD the Headquarters for highest quality Metal Powders for every Powder Metallurgy need.

MD, the pioneer Metal Powder producer, is the only company producing a complete line of powders of such a wide range of metals and their alloys.

Remember
One Call
Does It All!



METAL POWDERS
METAL PIGMENTS
METAL ABRASIVES

METALS DISINTEGRATING COMPANY, INC.

Elizabeth B, New Jersey

Plants:

Elizabeth, N. J.; Manchester, N. H.;
Berkeley, Calif.; Emeryville, Calif.

SUBSIDIARY OF AMERICAN-MARIETTA COMPANY

WORLD'S LARGEST MANUFACTURER OF FINEST QUALITY METALS

British Ships ...

resents a basic criterion in the design of ships' structures. A resonance vibration method has been used to duplicate the fluctuating loads to which hull components are subjected. A main feature of the work was to determine the effectiveness of different forms of reinforcement in certain types of butt welds. It was found that under fatigue conditions these reinforcements tended to reduce the strength due to the discontinuities introduced and that the most effective connection was formed by direct butt welds of high quality.

Methodical and informed supervision of welding and weld inspection is necessary to maintain good standards of workmanship. Precautions must be taken to avoid cracking in welds. Radiography has proved a most valuable technique for the control of shipyard welders. There is a trend in the United Kingdom toward the use of radioactive isotopes in place of X-ray apparatus.

Structural design is an important factor. Sharp discontinuities or notch effects must be avoided to all practical limits. The eye of the designer or draftsman must be specially trained to detect and smooth out stress concentrations. In recent years significant changes have occurred in the general design of merchant ships. There is a trend toward increased weight with decreased buoyancy at the ends. Hogging moments in the loaded conditions are consequently more severe than those in cargo ships of the past, for which sagging in ballast was the more critical condition. In many welded ships the resulting compressive stresses in the bottom plating have led to the development of corrugated plating already mentioned.

REVIEWER'S NOTE—For parallel developments in the United States the reader is referred to the Third Technical Progress Report of the Ship Structure Committee, and to a paper entitled "Research Under the Ship Structure Committee". Both are contained in Bulletin 16 of the Welding Research Council, 29 West 39th St., New York 18, N. Y. (See also the series of articles on brittle failures starting on p. 83 of this issue of *Metal Progress*.)

M. E. SHANK

REYNOCELL

THE MIRACULOUS NEW MATERIAL WITH BOUNDLESS USES



In CONSTRUCTION

because of its light weight, insulation and fire, moisture, fungi and pest resistance . . . movable partitions • folding partitions • interior curtain walls • residential doors • industrial and garage doors • solar shades • advertising signs • lean-to bomb shelters • shelving, etc.



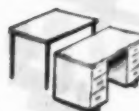
For PORTABLE EQUIPMENT

because of its light weight and structural strength . . . billboards • pallets • platforms • stage scenery • trailer and truck body parts • work stands, etc.



For INSULATED STRUCTURES

because of its excellent thermal insulation, light weight and strength . . . liners for refrigerator trucks and cars • walk-in refrigerators • refrigerated vending machines • shipping containers • oven jackets • heat baffles • preheating chambers • chicken incubators • bakery proof boxes, etc.



For FURNITURE

because of its modern beauty, light weight and fire and moisture resistance . . . desks and tables • cabinets • drafting boards • bed ends • store fixtures • portable bars, etc.



WHAT REYNOCELL IS:

Reynocell panels are extremely light, strong, rigid, prefabricated structural units. They have a honeycomb core of resin-impregnated kraft paper to which aluminum facings are securely bonded.

ITS PROPERTIES:

(Typical, based on 4" thick panels. Comparably favorable properties apply to other thicknesses.)

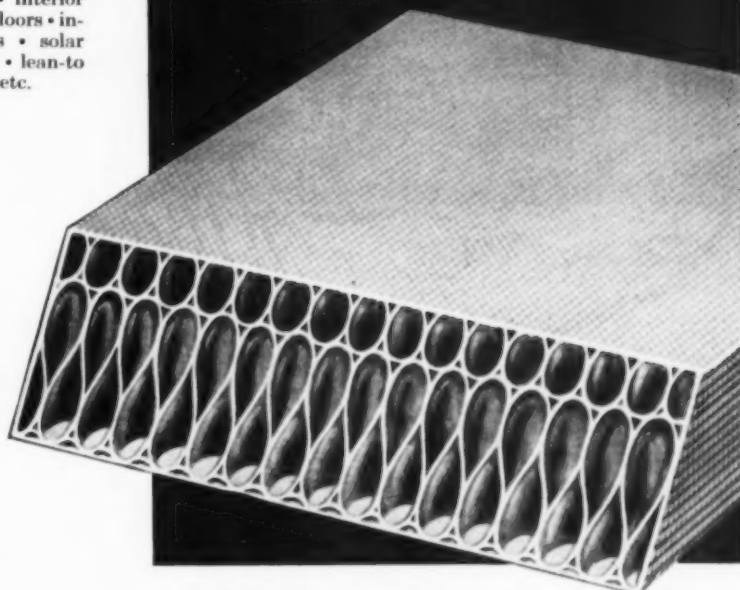
Weight — 1.46 lb./sq. ft.

Bending Strength — 180 lb./sq. ft. of uniformly distributed load on 8' span

Deflection — $\frac{1}{4}$ " with 47 lb./sq. ft. of uniformly distributed load on 8' span

Crushing Strength — 70 psi

Thermal Insulation (U factor) — .135



REYNOLDS Engineering Service

Reynolds engineers are working with a number of manufacturers on a variety of applications. Their assistance is also available to help you apply the many advantages of Reynocell Panels to your products.

Call your nearby Reynolds office listed under "Aluminum" in classified phone directories. Or write for more complete information and answers to your design questions. New applications and test data that may be helpful to you are accumulating every day. Reynolds Metals Company, 2519 So. Third Street, Louisville 1, Kentucky.

*T.M. registered

REYNOLDS



ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

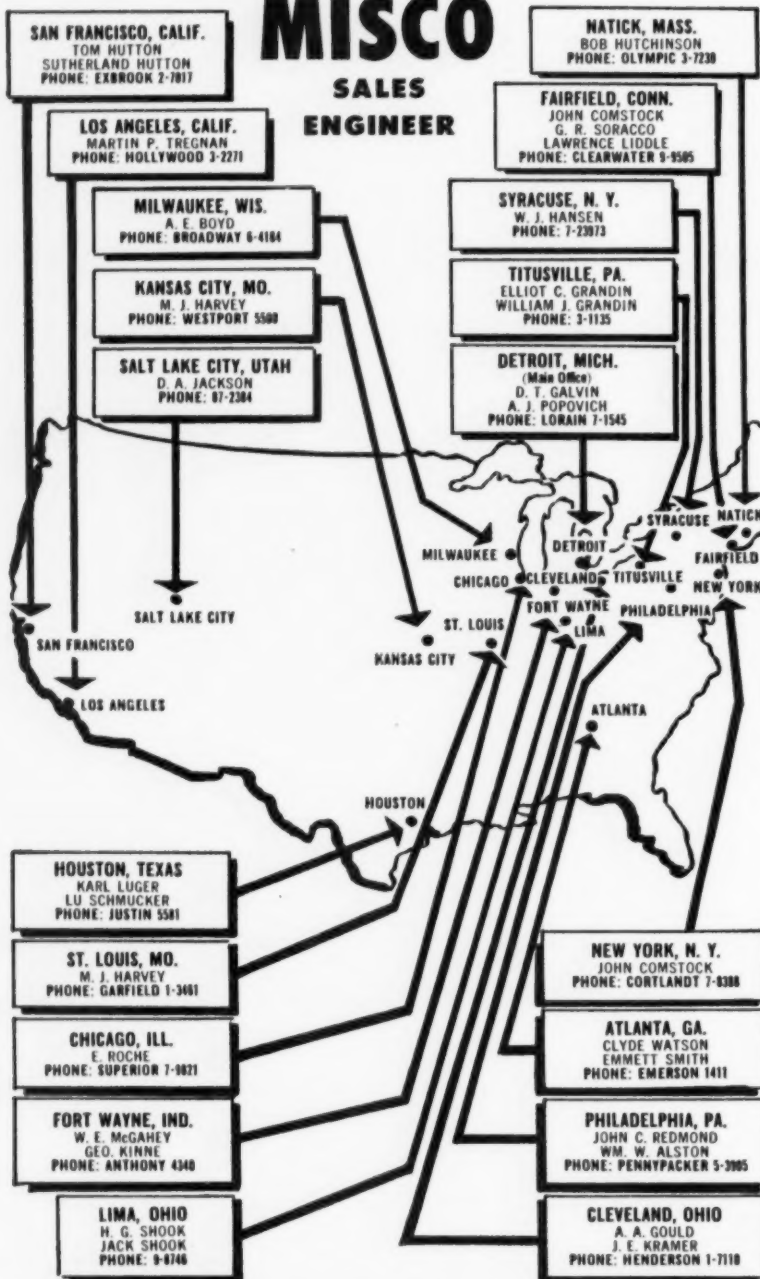
HELP Yourself

GET THE BEST IN HEAT AND
CORROSION-RESISTING EQUIPMENT

PHONE THE NEAREST

MISCO

SALES
ENGINEER



MISCO FABRICATORS, INC.

*Designers, Builders, Fabricators of Heat Resisting Alloy
and Stainless Steel Equipment*

1999 GUOIN STREET • DETROIT 7, MICHIGAN
TELEPHONE LORAIN 7-1545

Zirconium Additions Inhibit Grain Growth in Extruded Al*

NONUNIFORM grain size is commonly found in aluminum extrusions — in particular, a localized zone of coarse grain is frequently found after heat treatment, forming an annulus within the section or sometimes a ring around its circumference. The origin of the localized zone of coarse grain lies in the formation during extrusion of fine grain, which frequently shows strongly preferred orientation, and subsequent grain growth on heat treatment. Practical effects of this coarse grain include inferior mechanical strength in the regions of large grain, variations in mechanical properties across the extruded section and reduction in shear strength at the interface between coarse and fine-grained zones.

Considering the problem in broad terms, it is clear that heterogeneity of the type mentioned can be combatted in at least three ways: (a) by modifying the conditions of extrusion, (b) by introducing additional hot work and its associated recrystallization, (c) by altering recrystallization characteristics by modifying the heat treatment cycle or chemical composition.

It has been found in practice that of all the possible factors that can be varied under the heading "extrusion conditions", the design of die in relation to the container is the most significant. Other possibilities, such as to use indirect extrusion or to accept a high scrap loss on each extruded length, find little favor for economic reasons.

Technically, the application of a further hot working process after extrusion would counter the grain size problem, but it is clearly possible only with sections having very simple geometry.

The most significant possibilities emerge from the third group, which concerns recrystallization characteristics. A considerable amount of data
(Continued on p. 190)

*Digest of "The Influence of Additions of Zirconium on the Crystal Structure of Extruded and Heat Treated Aluminum Alloy Semifinished Products", by J. Herenguel and M. Scheidecker, *Revue de Metalurgie*, Vol. 51, March 1954, p. 173-178.

"We specify NICHROME*

because it gives

LOWEST HEAT-HOUR COST"

says **NASH MOTORS**



The Nash-Healey LeMans hardtop sports car



Carburizing trays of cast Nichrome used by Nash Motors for carburizing pinions, bevel gears, and miscellaneous small gears. The trays are used in a Surface Combustion pusher-type furnace, with 4 zones of temperature control: at 1550°F., 1700°F., 1700°F., and 1525°F.

Each tray is in the furnace approximately 8 hours, carries a gross load of about 80 lbs. The carburizing temperature is a mixture of RX gas and propane. After discharge from the furnace, the trays, together with the pinions and small gears, are quenched in an oil bath.

8 HOURS in the carburizing furnace, with 3 temperature changes. Then rapid cooling, followed by quenching in an oil bath. Then back into the furnace. That's the kind of service Nash Motors demands of their carburizing equipment.

And that's why they chose Nichrome for the trays shown here. For Nichrome *stands* this kind of service . . . gives a far lower heat-hour cost than any other equipment they have used.

"Estimated life of these trays is two years" says Mr. C. A. Jorgensen, Assistant Plant Engineer at Nash Motors. "Trays purchased before order M-80 went into effect [AUGUST, 1951] are still in serviceable condition, and we do not expect to replace them for some time to come."

*T.M. Reg. U.S. Pat. Off.

Whatever your heat treating requirements, consult with us.

Our business is keeping your heat-hour costs down to the absolute minimum—and we've had over 30 years of successful experience at doing just that.

Our engineers will be happy to make recommendations for your specific needs.



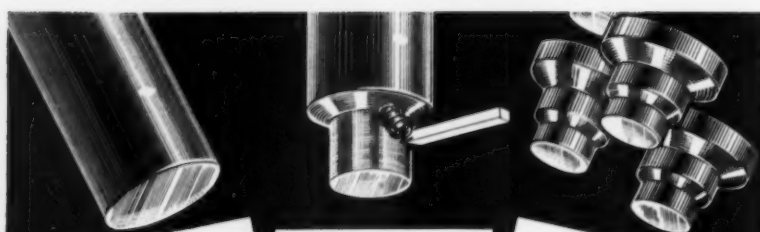
Nichrome is manufactured only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville, Los Angeles, San Francisco

MAKERS OF WORLD-FAMOUS NICHROME AND OVER 80 ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING FIELDS



Minimize
WARPAGE or
DISTORTION

Speed
MACHINING

Increase
PRODUCTION

*BUILT-IN to your production stock
when it's*

WYCKOFF

COLD FINISHED STEEL

CARBON... ALLOY... LEADED

You can always be sure with

- Wyckoff Controlled Quality Carbon, Alloy and Leaded Steels
- Turned and Polished, Ground and Polished Shafting
- Strain and Stress Relieved, Annealed, Heat-Treated, Quenched and Tempered Steels
- Wide Flats up to 12" x 2"



FULL COLOR
SPARK TESTING FILM
AVAILABLE

This fast, inexpensive, non-destructive testing method identifies metals by analyzing the elements present. The film presents some of the fundamentals.

Address requests for showings to our general offices.



WYCKOFF STEEL COMPANY

General Offices: Gateway Center • Pittsburgh 30, Pa.

Branch Offices in Principal Cities

Works: Ambridge, Pa. • Chicago, Ill. • Newark, N. J. • Putnam, Conn.

Grain Growth...

has been accumulated on the effects on grain size and mechanical properties of variations in solution heat treatment and it is established that the range of times and temperatures within which satisfactory solution heat treatment can be effected is very restricted. The limiting factors are those governing adequate solution of second phase, grain growth and minimum time for attainment of temperature uniformity. Factors of additional, but secondary, importance are overheating temperature and maximum time of treatment economically feasible.

Advantage can be taken, however, of changes which can be brought about in recrystallization characteristics by modification of composition. Manganese has been well established for its effect in retarding recrystallization and extending the time-temperature range, without excessive grain growth. For example, solution treatment at 895° F. must be confined to about 6 min. to avoid excessive grain growth in a low-manganese alloy. Addition of 0.6 to 0.8% manganese extends the "safe" period at that temperature to at least 1 hr.

Zirconium has been found to act similarly and even more potently and to exert its effect in a wide range of aluminum alloys. The relative effects of manganese and zirconium show up in alloy A-ZG containing 2% silicon and 3.25% magnesium in which recrystallization begins at about 750° F. in the absence of special additions, near 930° F. when 0.8% manganese is added, and above 975° F. when 0.2% zirconium is added. The influence of zirconium is progressive but in practice the zirconium content should not exceed 0.2% and best results are had with both zirconium and manganese.

Zirconium can be added by use of a master alloy containing 5% zirconium in aluminum, or by way of a slag (for example, a slag containing fluozirconate); either method is found to give consistent results.

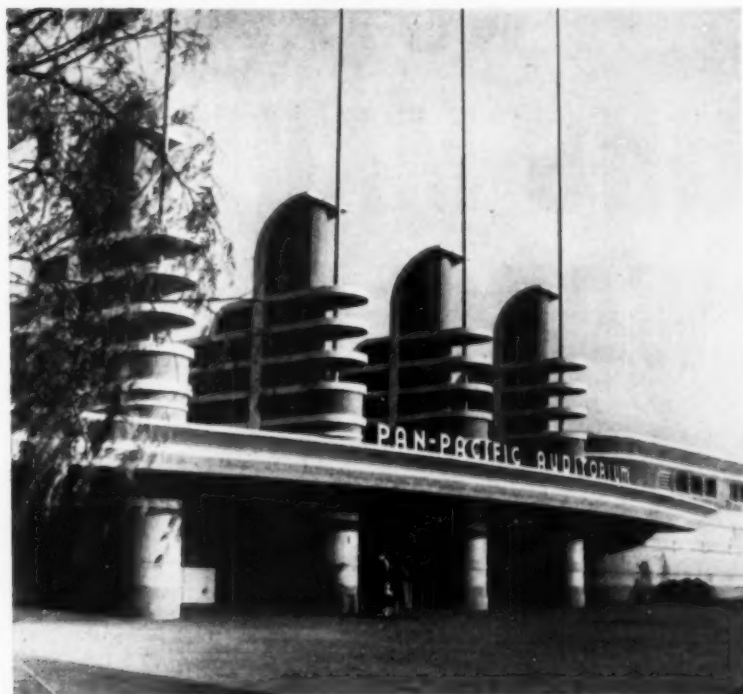
While the merits of zirconium in retarding recrystallization and grain growth and so countering the grain size effect are potentially very important in the extrusion of aluminum alloys, it must, however, be accepted that the high cost of zirconium is a limiting factor. C. B. LANDER

'55 WESTERN METAL EXPOSITION

and CONGRESS

**Pan-Pacific Auditorium
Los Angeles**

MARCH 28—APRIL 1, 1955



Grown Great Thru Service!

9th of a distinguished and successful series of Western Metal Expositions . . . the 1955 event promises even greater rewards . . . for exhibitors and visitors alike, than have ever before been achieved in these time-proved events! Months away . . . interest has sharpened and activity has mounted to indicate a record-breaking number of products and services displayed before record-breaking audiences . . . historic proof of the outstanding significance of these great Metal Shows!



Pan-Pacific Auditorium LOS ANGELES

best-known and most accessible exhibit hall in the west . . . will again be the scene of the Exposition.

Ambassador Hotel OFFICIAL HEADQUARTERS

for The Western Metal congress—make reservations now for March 28-April 1, 1955.

THE AMERICAN SOCIETY FOR METALS

7301 Euclid Avenue • Cleveland 3, Ohio

W. H. EISENMAN, Managing Director

Chester L. Wells, Assistant Director

LITCHFIELD PRODUCTS COMPANY

NOW ROLL WASHING MACHINE WORM GEARS

STRESSPROOF®

SEVERELY COLD-WORKED, FURNACE-TREATED
STEEL BARS

... CUT COSTS 40%

For years, STRESSPROOF has been recognized as an ideal worm gear steel. Several washing machine worm gears have been particularly successful. STRESSPROOF worms *outwear* the washing machine. STRESSPROOF's *ease of machinability* and *elimination of heat treating* keep costs down.

Now, the Litchfield Products Company, Litchfield, Michigan, roll the worm on this part for one of the largest washing machine manufacturers. The savings of 40% on the part cost is evident. Lead and pitch diameter requirements are maintained.

And there is no question as to gear life. STRESSPROOF's rugged wearability takes care of that whether the gear be cut or rolled.

STRESSPROOF makes a better part at lower cost. It's available in cold-drawn or ground and polished finish.

ASK FOR . . . your copy of this bulletin,
"New Economies in the Use of Steel Bars."

This washing machine worm gear is rolled from STRESSPROOF by LITCHFIELD PRODUCTS CO., Litchfield, Mich.



La Salle STEEL CO.

Manufacturers of the Most Complete Line
of Cold-Finished Carbon and Alloy
Steel Bars in America

La SALLE STEEL COMPANY
1424 150th Street
Hammond, Indiana

Please send me your new bulletin entitled,
"New Economies in the Use of Steel Bars."

Name _____
Title _____
Company _____
Address _____
City _____ Zone _____ State _____



Longevity

Rather an unusual word to apply to castings . . . length of life . . . but manufacturers who use ACCOLOY castings find it profitable when they have fewer breakdowns in production schedules and less replacements to make. Tell us your requirements. You too, can have the same advantage when you buy ACCOLOY Heat and Corrosion Resistant Castings.



ALLOY ENGINEERING & CASTING CO.

ALLOY CASTING CO. (Div.)
CHAMPAIGN • ILLINOIS

ENGINEERS AND PRODUCERS OF HEAT AND CORROSION RESISTANT CASTINGS

"SERV-RITE"

Insulated Thermocouple Wire Extension Lead Wire

FOR

PLATINUM COUPLES
CHROMEL ALUMEL
IRON CONSTANTAN
COPPER CONSTANTAN
IRON CUPRONEL

No matter what your wire or insulation requirements may be, you can depend on Gordon "Serv-Rite" insulated wire for pyrometers—recognized as a standard of highest quality for nearly half a century. All "Serv-Rite" wire is now manufactured in the new, completely modern Gordon plant, employing up-to-date equipment and machinery, supervised and operated by skilled technicians—your guarantee of continued precision quality. In addition to maintaining large stocks of all common types of wire, Gordon will manufacture special insulation, in long or short runs, to suit your individual needs and meet your most rigid specifications.

All Types of Insulation



The home of "SERV-RITE"

Full Particulars on Request

**GORDON
SERVICE**

CLAUD S. GORDON CO.

Manufacturers & Distributors

Thermocouple Supplies • Industrial Furnaces & Ovens
Pyrometers & Controls • Metallurgical Testing Machines
Dept. 15 • 3000 South Wallace St., Chicago 16, Ill.
Dept. 15 • 2035 Hamilton Ave., Cleveland 14, Ohio

Research in the United States*

THE PURPOSE of this paper is to define the different American research organizations, grouping them according to their origin—governmental, educational, industrial, cooperative or private—and to compare them with European research organizations. The ideas and opinions expressed are the result of a two-month trip to the U. S. and are based largely on direct observation.

In his attempt to reveal certain aspects of the influence of research on the success of American industry (which was the aim of the O.E.E.C. mission of which he was a member), the author devotes considerable attention to the close relationship of technical research with the aforementioned organizations. He observes that the commercial point of view predominates in research sponsored by industry and to this end the primary interest is directed to realizing economy of time and economy of materials. As a consequence, the product that is evolved is not the best possible product but one that is satisfactory and of low cost.

That the utilitarian value of this country's industrial research seems to have made a profound impression on the author—at least it will strike one who has lived with this attitude that he is so impressed—is evident throughout the report. He does not overlook the economist, the business man and financier and their roles in research—this research beginning with a study of the market and the careful selection of a research project, both of these being selected on their economic worth. The goals of industrial research as outlined in a company publication are cited as being typical of the American attitude:

1. To solve, or better anticipate, difficulties relative to raw materials, manufacturing methods, manufactured products; to improve production techniques.
2. Reduce expense at each stage.
3. Improve the quality of raw materials and products.

(Continued on p. 196)

*Digest of "Research—One of the Factors in the Industrial Success of the United States", by Georges Delbart, *Fonderie*, January 1954, p. 3745-3754 (translated by Dorothy F. Thum).

Which do you use?



Both oxides have definite advantages for specific uses due to their particular physical and chemical properties. Study the comparative information given here and see which will answer your requirements best.

Make note of the fact that our pure (monoclinic) oxide can be furnished in the finest grain size obtainable. We believe the purity of our oxides is unexcelled.

Typical Analysis

Pure Oxide (Monoclinic 99.2% ZrO ₂)				
SiO ₂	TiO ₂	Fe ₂ O ₃	Al ₂ O ₃	BaO
.06	.05	.02	.02	.003
CaO	MgO	K ₂ O	Na ₂ O	B ₂ O ₃
.56	.04	.005	.004	.001

Stabilized Oxide (99.7% Cubic)				
SiO ₂	TiO ₂	Fe ₂ O ₃	Al ₂ O ₃	BaO
.16	.10	.11	.05	.003
CaO	MgO	K ₂ O	Na ₂ O	B ₂ O ₃
5.20	1.01	.001	.003	.001

Use Characteristics

Different crystal structures account for the different successful uses of these two oxides. Pure oxide, having monoclinic crystals, undergoes an inversion of crystal structure and a 7 per cent volume change at about 1000° C. The introduction of calcium oxide, during the process of creating stabilized oxide, locks each crystal in a cubic form which remains constant to its melting point of 4700° F. The other important difference between these two oxides is the necessarily larger percentage of calcium present in the stabilized oxide.

A-9079

FREE SAMPLES of either oxide are available on request. Perhaps we can help you with your particular application.

Write Zirconium Corporation of America, Solon Blvd., Solon, Ohio.



Twelve Papers on Furnace Atmospheres To Be Given At Metal Show On IFMA Day!

Protective atmospheres are saving money, improving quality, and speeding production in the metalworking industry. But, based on numerous inquiries received by the Industrial Furnace Manufacturer's Association (IFMA), it became apparent that there was a definite need for a logical, orderly collation of the latest thought on the process.

Months of planning by a special IFMA committee will be culminated on Tuesday, November 2nd, IFMA Day, at the Metal Show in Chicago when twelve national authorities will present the latest theory and practice on the generation, control and application of furnace atmospheres.

The panel type sessions will start in the morning at the Palmer House with a paper by A. Hotchkiss on the theory of atmosphere gases. Following papers by W. Boyd, D. Beggs, M. Ogle, N. Koebel and R. J. Perrine will discuss in detail the construction and operating techniques of atmosphere generators. The morning session will close with a report by W. Besselman on

control and safety in the use of atmospheres.

In the afternoon, the sessions will shift to the Exhibition Hall, the site of the Metal Show. Papers on the applications of furnace atmospheres will be given by W. Holcroft, D. Cullen, H. Ipsen, A. Frank and C. Paulson.

A new movie on the brazing process will be shown.

Extensive correspondence between participating speakers has eliminated any possibility of repetition of material. A 12 minute time limit for each subject assures that only the important theories, facts and problems will be discussed.

Future issues of METAL PROGRESS will report each paper in detail. At a later date, it is expected that the papers will be incorporated into an authoritative text.

IFMA is also participating in a similar panel type session on high frequency induction heating to be held in conjunction with the Metal Show. Details will be announced shortly.



Cary H. Stevenson will act as moderator at panel session.

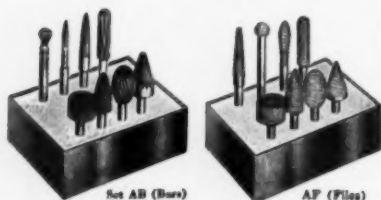


Les H. Gillette, President, Industrial Furnace Manufacturers Association

MARTINDALE

ROTARY BURS AND FILES

Made of high-speed steel. Produced in our own factory where uniform hardness is assured by heat-treating in electric furnaces on which the temperature is closely controlled by electric eyes.



The above sets, with 1/4" diameter shanks, are composed of the 8 most popular sizes for general use.

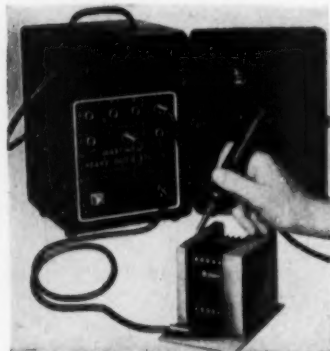
Over 200 sizes and shapes (total over 75,000 pieces) are carried in stock for immediate shipment.

DEMAGNETIZER—Model D-3



This tool quickly and easily removes magnetism from cutting tools such as cutters, drills, saws, etc., and thus keeps them free from chips and metal-slivers that reduce production. Cuts cost of tool maintenance.

HEAVY DUTY ETCHER



Model A-A has wide use as a production-line etching tool. With six heats it is effective on small parts and also on large pieces such as shovels, castings, etc. Complete with ground lead, heavy metal case, etc.

Send for Catalog with 64 pages of Maintenance, Production and Safety Equipment.

MARTINDALE ELECTRIC CO.

1372 Hird Avenue, Cleveland 7, Ohio

U. S. Research...

4. Reduce expense of upkeep and of consumer use.

5. Investigate the application of materials and new processes.

6. Develop satisfactory substitutes.

7. Recuparate and utilize by-products and waste.

8. Accumulate technical knowledge and information.

9. Develop markets.

A very important consideration, even a predominant one, is given to engineering: the effort that pertains to the transition of laboratory discoveries to factory products, a process that is generally identified in this country by the word "development". The European researcher, concerned with his pride of dignity and his disinterestedness, has for a long time underestimated the importance of development. For the American, development is an essential part of industrial research; in fact, the American administrator of industrial research considers that for each laboratory researcher approximately ten engineers and technicians are necessary for development. Which gives an idea of the importance of this concept.

General control of research in the big industrial companies is in charge of one of the vice-presidents; such an administrator is not common in Europe. Also uncommon in Europe are the special courses in management and organization that are offered in American universities. The author remarks that research administrators are generally mature men and often graybeards, but research directors and researchers are very often young, the experience of older men thus being combined with the enthusiasm and creative faculties of young researchers.

In undertaking to compare American and European technical research, the advantages and limitations of each with regard to factors of a geographic, political, economic, fiscal, technical and psychological nature should be kept in mind, for they differ considerably.

The European researcher is often of the university tradition, independent and haughtily disinterested—even to an attitude of romanticism. There are many exceptions and these

(Continued on p. 198)

Eliminate Corrosion from Electrical Contacts with RHODIUM PLATING

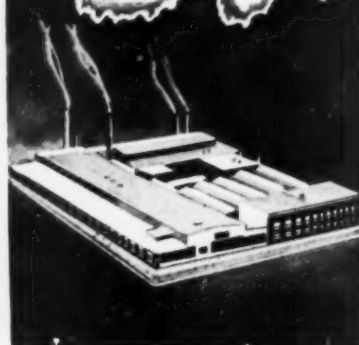
Rhodium plating is finding increased use by electronic design engineers where hard, corrosion resistant electrical contact surfaces are required. Rhodium provides a stable contact resistance and allows use of higher pressures in sliding contacts.

Rhodium is not affected by atmospheric changes, is free from oxide rectification and provides a low noise level. It finds many applications in the printed circuit field where it permits incorporation of sliding contacts as part of the circuit.

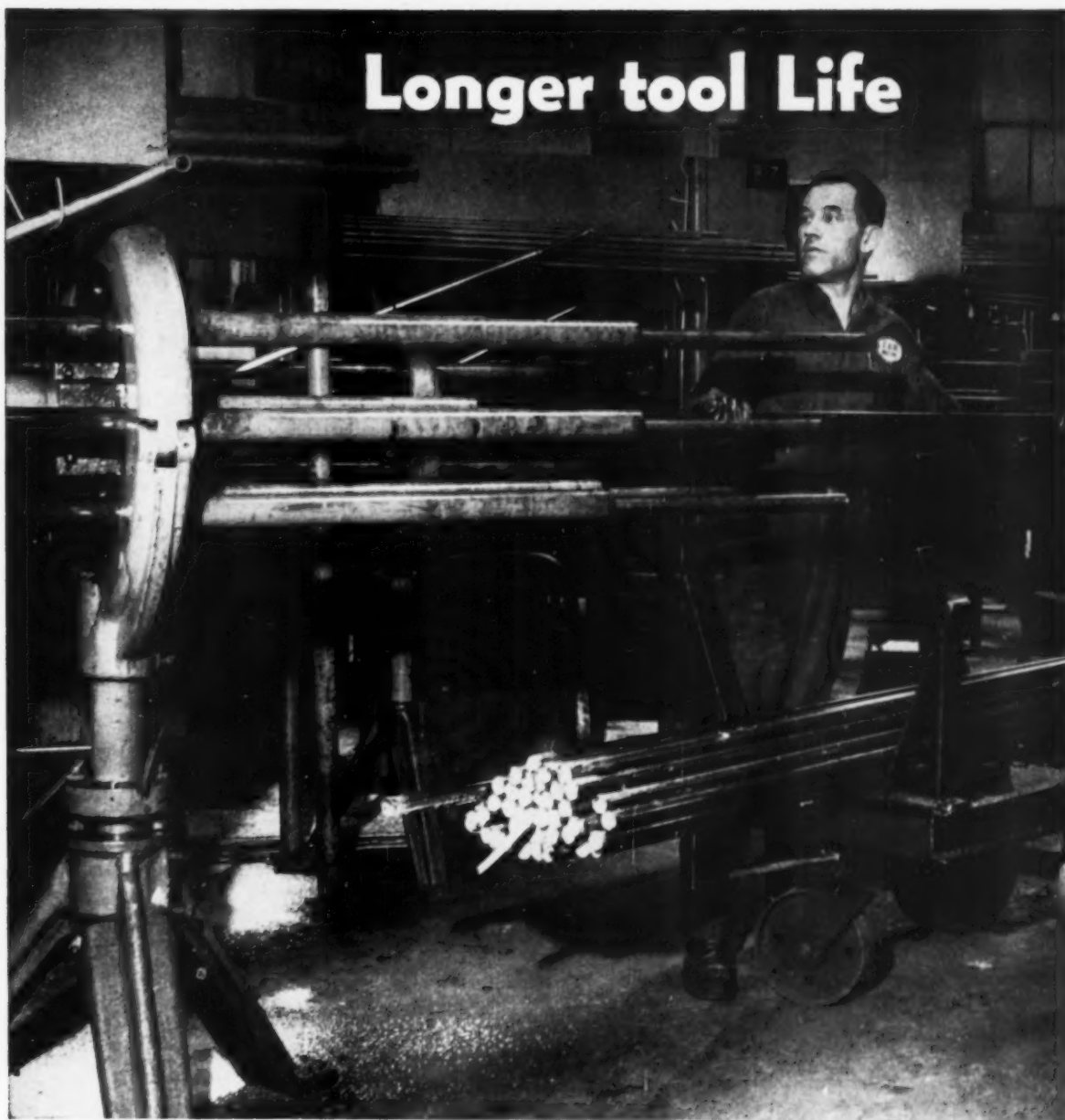
Write for Booklet 16.

BAKER & CO., INC.

113 ASTOR STREET, NEWARK 5, N. J.
NEW YORK • SAN FRANCISCO • LOS ANGELES • CHICAGO



Longer tool Life



Youngstown



**COLD FINISHED CARBON AND
ALLOY STEEL BARS**

●A battery of machines consume tons of screw machine cold finished bar stock. Yet, tool wear is normal when it's Youngstown steel you're using. That's because composition, structure and surface conditioning, combined with "know how" in cold finishing, assure proper, scale-free machining stock. Use Youngstown Cold Finished Carbon and Alloy Steel Bars for longer tool life.

THE YOUNGSTOWN SHEET AND TUBE COMPANY

*Manufacturers of
Carbon, Alloy and Incoloy Steel*

General Offices: Youngstown, Ohio - Export Office: 500 Fifth Avenue, New York 36, N. Y.

SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT
AND EMT - MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - BAR SHAPES - WIRE
HOT ROLLED RODS - COKE TIN PLATE - ELECTROLYTIC TIN PLATE - RAILROAD TRACK SPIKES

U. S. Research . . .

exceptions may soon become the rule, but there is no question that the American is more utilitarian. The European researcher of university tradition is often willing to limit his efforts to bibliography and laboratory research, whereas the American concentrates on the paying project and on development—often using the laboratory research of the European, who either supplies the ideas and the basic data or becomes an expatriate.

Basic research is certainly still honored in the U.S., but the fact is that industrial research is everywhere, even in the universities. This is in sharp contrast with the European universities which traditionally work in a disinterested way.

Although fundamental research has not been neglected in the U.S. (one has only to follow the scientific publications for proof), there has been deviation, and utilitarian research has made serious invasion upon the time and effort that should

be devoted to it. The U.S. government, itself largely responsible for this state of affairs, is now trying to rectify the condition.

The author concludes with strong emphasis on the important interpenetration which exists in the U.S. between research laboratories and various administrations. Organizations having diverse interests keep in touch with each other and with current events, and make a point of finding the center with the *ad hoc* equipment and the specialized scholar, and of using them on their own ground. These connections and interpenetrations put research men in contact with real life to the great profit of the community.

The author summarizes his opinion on the American approach to research with the admonition: "We must remember that in the ceaseless world struggle our research must be efficient; that is, it must be rapidly developed. That is why I will end this paper with the word so honored in the U.S.—development".

J. P. JR.

Steel Cartridge Cases*

CALIBER .45 steel cartridge cases were made in great numbers by Chrysler Corp. at Evansville, Ind., but this plant was dismantled at the end of World War II. In 1952 some of the stored machinery was put into a new operation at Twin Cities Arsenal by Federal Cartridge Corp. using substantially the old practice, and Mr. King says that either brass or steel cartridges can be made.

First operation is blanking disks and forming cups in a double-action press making five cups per stroke. Short punch and die life was cured by filtering the recirculating lubricant cleanly of metal fragments and using a lubricant with some bite, which would wet and stick to the smooth strip. After alkaline wash, 100% visual inspection rejects any scratched or otherwise defective cups. Annealed strip of high and uniform quality is necessary, free of laminations or inclusions.

Cups are then annealed in protective atmosphere—an operation of prime importance—in Lindberg or Sunbeam furnaces. Cups are loaded on a conveyer belt and stay 30 min. in the furnace, whose first zone is at 1320 and the second at 1400° F. A long cooling chamber delivers bright work to Stephens phosphating units (traveling barrels). Cases are alkaline cleaned, phosphated, and soap coated after each draw. Phosphate and soap have these advantages over Chrysler's use of a copper dip-plate: better corrosion protection; better tool life; easier removal at the end. Dies have carbide inserts; punches are of polished steel; coolant is dilute soap solution. Production of 400 per min. per press equals usual speed for brass cartridges.

After the second draw the cases are normalized 30 min. in a continuous furnace, 1600° F. in the first zone, 1725 in the second. The third draw gives the wall the correct thickness and diameter. Cases are trimmed to length, primer pocket formed, and extractor groove cut.

A certain proportion of caliber .45 cartridges have split when fired in the M3 submachine gun, due to lack of support (large clearances in the

(Continued on p. 200)

*Digest of "Steel Cartridge Cases", by William N. King, *Ordinance*, July-August 1954, p. 49.

GET THE FACTS

About Hardness Testing

Everything you need to know about hardness testing is told in this handsome book, prepared by the makers of the internationally respected CLARK Hardness Testers for "Rockwell Testing." Simple, easy-to-read text (in English) and numerous illustrations show the equipment and procedure for fast, accurate hardness testing of ferrous and non-ferrous materials. If you would like a copy, *free of charge*, just attach this ad to your letterhead or write "Send book." A copy will be mailed to you promptly.

P.S. If you are interested in descriptions and prices for CLARK Hardness Testers (Standard and Superficial) of *guaranteed accuracy*, say the word and we'll gladly supply them.

CLARK

CLARK INSTRUMENT INC.

10202 Ford Road • Dearborn, Mich., U.S.A.



Are your Alloy Steel Bars in the PROFIT AREA

for your MACHINE TOOLS?

It's the outer rim of a Republic carbon-corrected alloy steel bar that helps you make a profit. In the ordinary heat-treated bar this is a "decarb" area that usually must be removed before parts can be made from stock. In a Republic bar, the carbon has been restored after heat treating . . . right out to the edge.

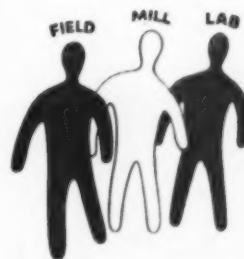
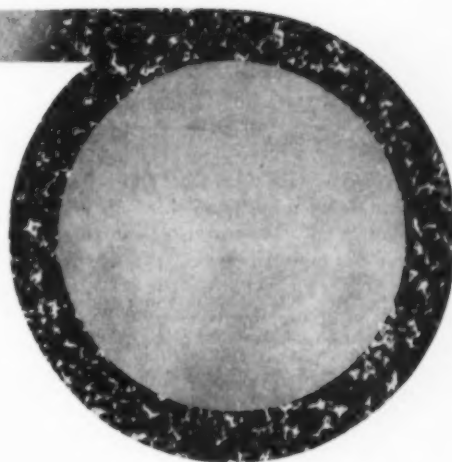
You don't machine away good metal into chips and shavings. And that can make a substantial difference in your profits.

Republic's 3-Dimension metallurgical service will be glad to show you how you can get in on such savings as these. It works with your metallurgists and production people to adapt cold-drawn carbon-corrected alloy steel bars to your product. The combined extensive experience and abilities of Republic Mill, Field and Laboratory metallurgists are added to the knowledge and skills of your engineers.

The result often means better products at reduced costs. Get in touch with your Republic Steel salesman. He can arrange for a Republic metallurgist to call at your convenience.

REPUBLIC STEEL CORPORATION
Union Drawn Steel Division • Massillon, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC COLD DRAWN
ALLOY STEEL BARS



3-Dimension Metallurgical Service

combines the extensive experience and co-ordinated abilities of Republic's *Field, Mill and Laboratory Metallurgists* with the knowledge and skills of your own engineers. It has helped guide users of Alloy Steels in countless industries to the correct steel and its most efficient usage, IT CAN DO THE SAME FOR YOU.

gun chamber). Specifications now allow only one-third the number of splits. This requires a stress-relief, 6 min. at 1250° F.

After inspection for size, the cartridge cases are zinc plated, chromated for rust resistance, and are ready for loading and priming.

Decision to make steel cartridge cases at Twin Cities Arsenal was reached late in 1952. Production started in May 1953. Scheduled production has been met or exceeded monthly since September 1953.

E. E. T.

Replacement of Mo by V for High-Tensile Steels*

THIS ARTICLE is a continuation of work by the British Welding Research Assoc. on a series of 35 experimental low-carbon weldable steels of high tensile strength last re-

*Digest of "Vanadium as a Replacement for Molybdenum in Low-Alloy Steels", by C. L. M. Cottrell and B. J. Bradstreet, *British Welding Journal*, Vol. 1, February 1954, p. 82-86.

ported in *Welding Research*, Vol. 7, August 1953. Two compositions known as A and B appeared most promising, composition of these being as follows: (A) — 0.13 to 0.17 C, 0.80 to 1.00 Mn, 0.30 (max.) Si, 0.50 to 0.70 Ni, 0.80 to 1.00 Cr, and 0.20 to 0.24% Mo; (B) — 0.13 to 0.17 C, 1.00 to 1.20 Mn, 0.30 (max.) Si, 0.20 (max.) Ni, 0.50 to 0.70 Cr, and 0.20 to 0.24% Mo.

The most recent work, summarized herewith, concerned 12 additional experimental steels based on the composition of steels A and B with vanadium replacing part or all of the molybdenum. To simulate the cooling conditions of 1½-in. thick plates, a "sandwich" technique was used whereby ½-in. square bars were

clamped between ½-in. plates for tensile tests, and ½-in. thick plate was clamped between ½-in. plates for Izod impact tests. The sandwiches were normalized by heating at 1650° F. for 1½ hr. and were then cooled in still air.

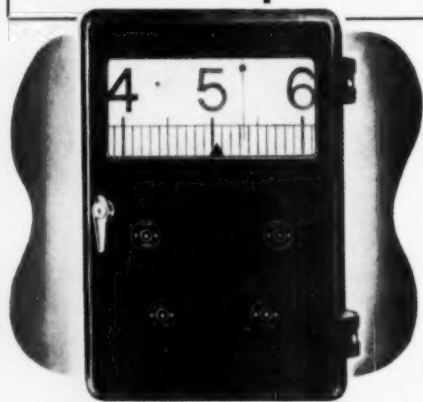
As shown by the following table, the significant effect of replacing about 0.23% Mo with about 0.13% V is to double the 0.02% proof stress with a substantial increase in ductility as measured by the reduction of area.

Izod (3-notch 10-mm. square) tests were run on steels of the A series and, as shown on p. 202, the vanadium steel (56) has better notch-toughness and a lower transi-

(Continued on p. 202)

	STEEL A	No. 56	STEEL B	No. 63
Carbon	0.14%	0.15	0.14	0.13
Manganese	0.89	0.78	1.14	1.13
Silicon	0.18	0.09	0.30	0.14
Nickel	0.56	0.73	0.23	0.12
Chromium	0.93	0.92	0.66	0.69
Molybdenum	0.22	—	0.24	—
Vanadium	—	0.14	—	0.12
0.02% Proof stress, psi.	29,100	59,100	26,200	55,200
Tensile stress, psi.	84,300	84,300	89,600	76,900
Reduction of area, %	63	72	59	75

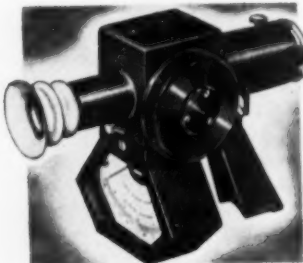
Most Complete Pyrometer Line in the World!



TELOSCALE INDICATOR

- Scales up to 3700° F.
- Scales readable at considerable distance.
- Effective scale size 55 inches.
- Screen size 11 inches.
- Various temperature scales available.

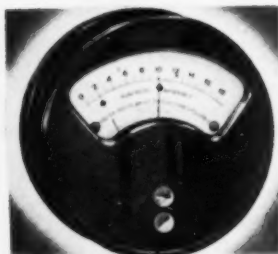
\$340 F.O.B. Boston



OPTICAL PYROMETER

- Disappearing filament type.
- Temperatures 1260° to 7200° F.
- Single and Multi-Ranges available.

\$222 F.O.B. Boston



5" SCALE CIRCULAR Temperature Indicator

- Completely shock-proof.
- 22mV at full scale.
- 15 feet of compensating cable as integral part of instrument.

\$77.50 F.O.B. Boston

WRITE FOR CATALOG

ANGLO AMERICAN SCIENTIFIC
185 DEVONSHIRE STREET, BOSTON, MASS.

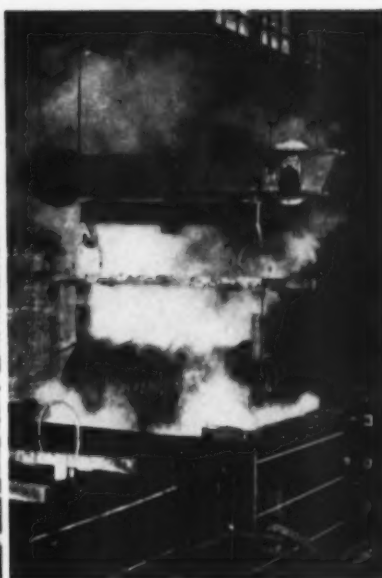
Representing FOSTER INSTRUMENTS, England



TOOL STEEL SHEETS



STAINLESS STEEL BAR STOCK



CARBON STEEL WIRE

You can safely descale most metals in 20 minutes or less

WITH THE DU PONT SODIUM HYDRIDE PROCESS



In 10 to 20 minutes, sheets, bars, wire, rods, forgings and fabricated articles are completely descaled with the Du Pont Sodium Hydride Descaling Process. Even heavily scaled forgings ($\frac{1}{2}$ " scale thickness) take less than an hour. And in only 15 seconds you can get cold reduced-

annealed strip clean and bright!

With hydride descaling, there's never any danger of etching or pitting . . . never a costly reject due to loss of gauge. Base metal is always protected, *since bath action stops the instant scale is reduced*. And retreatments are rarely needed with most metals. One pass through the sodium hydride bath will do the job completely.

TECHNICAL SERVICE AVAILABLE

If you are descaling metals which are unaffected by fused caustic at 700°F., it will be to your advantage to talk to us about the Du Pont Sodium Hydride Process. Du Pont pioneered this modern descaling method and can bring a depth of technical experience to bear on your descaling problems.

There's no cost for this service which includes laboratory investigation of problems, plus expert aid in construction, installation and operation of the process. Just call our nearest district office or send in coupon below.

DISTRICT AND SALES OFFICES: Baltimore • Boston • Charlotte • Chicago • Cincinnati • Cleveland • Detroit • Kansas City* • Los Angeles • New York • Philadelphia • Pittsburgh • San Francisco

*Baroda & Page, Inc.

Du Pont

Producer of Sodium

Pioneer of Hydride Descaling



REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING...THROUGH CHEMISTRY

FOR MORE INFORMATION

E. I. du Pont de Nemours & Co. (Inc.), MP-94
Electrochemicals Dept., Wilmington 98, Del.

- ☐ Please send me your free booklet on Sodium Hydride Descaling.
- ☐ Please have one of your technical men call. I am interested in descaling _____

Name _____

Firm _____

Address _____

City _____ State _____



Why wait for vacuum?

Vacuum work needs the speed of Kinney High Vacuum Pumps . . . to produce vacuums in the fractional micron ranges quickly and efficiently. These pumps retain better than 50% of their pumping speeds into the less-than-10-micron pressure zone. They are easy to start—require no warm-up or hand starting. Both employ the oil sealed pumping system pioneered and perfected by Kinney; your assurance of long, low cost service. Whatever your vacuum problem, it pays to pick a Kinney High Vacuum Pump. Competent vacuum engineers, located in all our district offices, are ready to help you get the right pump for your needs. Send coupon for details.



KINNEY MFG. DIVISION
 THE NEW YORK AIR BRAKE COMPANY
3004 WASHINGTON STREET • BOSTON 30 • MASS.

Please send Bulletin V-54.

Name

Company

Street

City State

High-Tensile Steels . . .

tion temperature than the molybdenum type:

TEST TEMPERATURE	IZOD, FT.-LB.	
	STEEL A	No. 56
68° F.	20	70
32	15	75
-4	8	60
-40	6	38

Minimum temperature for 50% sheer fracture was 86° F. for Steel A and -22° F. for Steel 56.

While no data were presented, the authors have rated the weldability of the vanadium steel as the equal of the standard molybdenum type (A and B).

In the series of steels investigated were some with about 0.22% V.; these showed little improvement in yield stress and a somewhat higher transition temperature than those with 0.14% V, so that there is no need to go beyond this level. Also, steels with lower Mo (about 0.15 to 0.19%) plus about 0.14% V had less desirable Izod values and weldability than the steels with vanadium but no molybdenum.

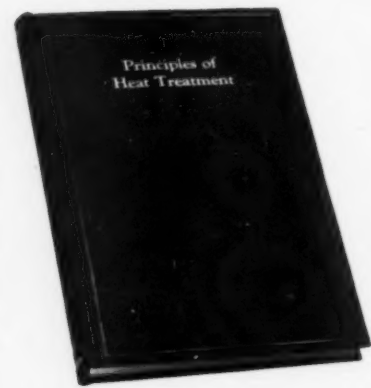
The improved yield and notch-toughness properties of the vanadium steels is attributed to their fine-grained ferritic-pearlitic structure, whereas the molybdenum steel contained a small amount of the lower bainite structure. The authors believe that tempering the molybdenum steels improves yield strength and lowers transition temperature.

The findings of this investigation are in good agreement with the relative effect of molybdenum and vanadium on the normalized properties of low-alloy steels in this country. It is doubtful that the properties reported for normalized 1½-in. thick plate could be consistently maintained in as-rolled plates because of the effect of variations in finishing temperature on the solubility of vanadium carbide as well as on the grain size. Still, the preferred composition would require normalizing.

American developments, utilizing vanadium in low-alloy steels for high yield strength, high notch-toughness and good weldability, have been directed toward still lower levels of vanadium (less than 0.10%) with results, in general, quite similar to those reported here.

P. R. WRAY


Now . . . the Fourth Great Edition




"PRINCIPLES OF HEAT TREATMENT"

by Dr. Marcus A. Grossmann

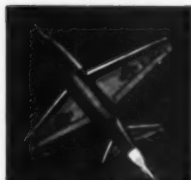
A storehouse of vital, useful and helpful information on every phase of heat treatment . . . job-tested processes and tricks of the trade that will help you do a better job . . . help you cut costs and boost production and greatly sharpen and broaden your knowledge of the right move at the right time!

. . . another 
Masterpiece of Treatment Data!

Write today to  headquarters! Attach your check and this great book will be on its way to you! **\$5⁰⁰**

American Society for Metals
 7301 Euclid Avenue
 Cleveland 3, Ohio

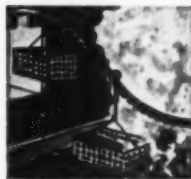
How long will this valve last?



Hoskins Chromel-Alumel thermocouple alloys accurately register exhaust temperatures of jet aircraft engines.



Heating elements made of Hoskins Chromel give long life service in industrial electric furnaces, home appliances.



Hot stuff for hot jobs! Hoskins Alloy 502 is widely used by industry for many heat resistant mechanical applications.

You're looking in on a life-saving operation . . . one that's being performed on an engine valve. Not an ordinary valve for an ordinary engine. But a valve destined for long, hard service in an aircraft, tank, or heavy-duty truck engine. A valve that must be made to stand up under extremely severe operating conditions . . . high temperatures, for long periods of time, plus the destructive corrosive action of hot exhaust gases.

And what's responsible for long valve life under such gruelling conditions? Nothing less than Hoskins Alloy 717 . . . a closely controlled nickel-chromium composition developed especially for just such tough and vital service. It's highly resistant to heat . . . immune to the corrosive atmospheres created by combustion of high octane fuels. What's more, it's readily applied

by fusion to form a non-porous protective facing over the basic valve forging.

But 717 is only one of several specialized nickel-chromium alloys developed and produced by Hoskins. Among the others: Alloy 502 . . . known throughout industry for its dependability on a wide range of heat resistant mechanical applications. The Chromel-Alumel thermocouple alloys . . . unconditionally guaranteed to register true temperature—E.M.F. values within specified close limits. Spark plug electrode alloys which have become universally accepted standards of quality and durability. And, of course, there's Hoskins CHROMEL . . . the *original* nickel-chromium resistance alloy used as heating elements and cold resistors in countless different products.

HOSKINS
MANUFACTURING COMPANY

4445 LAWTON AVENUE, DETROIT 8, MICHIGAN

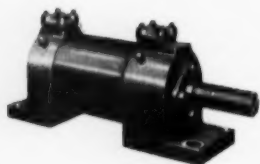


More *modern* Industries

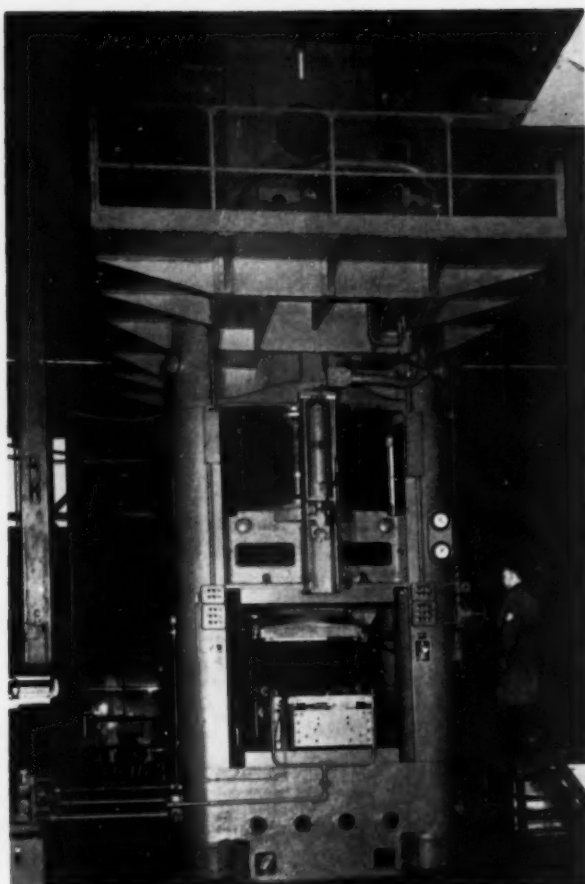
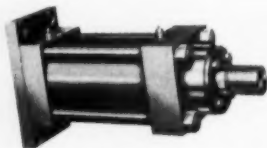
than ever before
are now specifying

ACIPCO STEEL Centrifugally Spun TUBES for . . .

- ALL TYPES OF ROLLS
- HYDRAULIC CYLINDERS
- FURNACE TUBES
- CHEMICAL RETORTS
- MANY OTHER INDUSTRIAL APPLICATIONS



ACIPCO STEEL centrifugally spun tubes were employed in the construction of the 3000 psi (above) and 2000 psi (below) hydraulic cylinders.



NEEDLESS TO SAY, the hydraulic press shown above and others like it must be built to withstand a lot of rugged punishment. Many of these industrial giants employ various types of hydraulic cylinders constructed of ACIPCO STEEL centrifugally spun tubes for shuttle feed use and the like.

ACIPCO STEEL tubes are serving in countless industrial uses and their exceptional value as a component in weldment applications is widely recognized. Tubes can be furnished in all the alloy grades including heat and corrosion resistant stainless steels as well as plain carbon grades. Special non-standard analyses are also available. ACIPCO tubes are manufactured in lengths up to 16 feet with wall thicknesses from .25" to 4". Outside diameters range from 2.25" to 50" and in large sizes ACIPCO tubes have a decided economical advantage over hollow-bored forgings.

In ACIPCO tubes there is an absence of directional lines of weakness found in hot rolled or cold drawn tubing. Tubes can be furnished rough as-cast, finished machined or honed to your specific need.

AMERICAN CAST IRON PIPE COMPANY

Special Products Division
Birmingham 2, Alabama

NOW AVAILABLE without charge. "ACIPCO STEEL Centrifugally Spun Steel Tubes"—a new 16mm sound motion picture in color (33½ minutes) showing ACIPCO's centrifugal tube-making process. Write ACIPCO, P. O. Box 2603, Birmingham 2, Alabama.

Distributors:

Austin-Hastings Company, Inc.
226 Binney Street
Cambridge 42, Massachusetts

Peter A. Frasse and Co., Inc.
17 Grand Street
New York 13, New York

Strong, Carlisle & Hammond Co.
1392 West Third Street
Cleveland 13, Ohio

Lyman Tube and Bearings, Ltd.
520 Ste. Sophie Lane
Montreal 3, Canada

J. M. Toll Metal and Supply Co.
785 Marietta Street, N.W.
Atlanta, Georgia

Dacomun Metals & Supply Co.
4899 South Alameda Street
Los Angeles 34, California

C. A. Roberts Company
20 South Aberdeen Street
Chicago 7, Illinois

T. E. Rybka
South Park Road—R.D. 4
Liberty, Pennsylvania



Baldwin's low-cost 60-H makes testing easy for the University of Pittsburgh

For testing parts of naval aircraft the University of Pittsburgh's Engineering Research Division uses the Baldwin 60-H. Also secondary load measuring devices such as dial type dynamometers and tension bars with SR-4 strain gages are calibrated by this testing machine.

Pitt chose the Model 60-H for testing economy and simplicity. And they've found this low-priced, easy to operate machine enables engineering students to do most of the test work. Its convenient control system, many automatic safety features and simple maintenance make testing at Pitt an easy and trouble-free operation.

The Baldwin Model 60-H gives the University of Pittsburgh *all* these testing benefits.

1. Simple operation makes it easy for engineering students to do test work.

2. The machine meets *all* requirements at low cost.
3. Accuracy of load measurements is well within laboratory requirements.
4. Separate frames for loading structure and indicator prevent transmission of shock when test specimens break.
5. Scale ranges of 0-12,000 lbs. and 0-60,000 lbs. are exactly suited to stress ranges of the test work.

Like the University of Pittsburgh, you can have *all* these benefits with the Baldwin Model 60-H. You'll learn that Baldwin designs testing machines to give outstanding performance. For more information about the Baldwin Model 60-H and other testing equipment, write now to Dept. 2524, Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

TESTING



HEADQUARTERS

BALDWIN - LIMA - HAMILTON

General Offices: Philadelphia 42, Pa. • Offices in Principal Cities

In Canada: Peacock Bros., Ltd., Montreal, Quebec

NOW... Pre-cast Core Oven Roof Sections of REFRACTORY CONCRETE

Pennsylvania Plant Takes Advantage of New Pre-Casting Technique

Flat-arch core oven roofs can be pre-cast quickly and easily with a new technique like the one used at Penn Steel Castings Company, Chester, Pa. (see photos). In this case, plant personnel cast monolithic roof sections on the job, then lowered these panels into place to complete the flat arch.

Refractory concrete makes possible special panels like these, and this is only *one* of the many ways that Lumnite® calcium-aluminate cement serves Penn Steel Castings Company. It stops heat loss in annealing furnaces and pits...insulates annealing car bottoms...serves as core oven floors. With Lumnite cement and suitable aggregates, refractory concrete can be made to take temperatures up to 2600 F., or more. Repairs can be made rapidly because refractory concrete aids easy placement and reaches service strength in 24 hours!

FOR CONVENIENCE, you may prefer to make refractory concrete with prepared castables (packaged mixes of Lumnite Cement and aggregates selected for specific temperature and insulation service—add only water). They are made and distributed by refractory manufacturers. For more information, write Lumnite Division, Universal Atlas Cement Company (United States Steel Corporation Subsidiary), 100 Park Avenue, New York 17, N. Y.

*"LUMNITE" is the registered trade-mark of the calcium-aluminate cement manufactured by Universal Atlas Cement Company.

MP-L-91

ATLAS®

LUMNITE for INDUSTRIAL CONCRETES

REFRACTORY, INSULATING, OVERNIGHT, CORROSION-RESISTANT

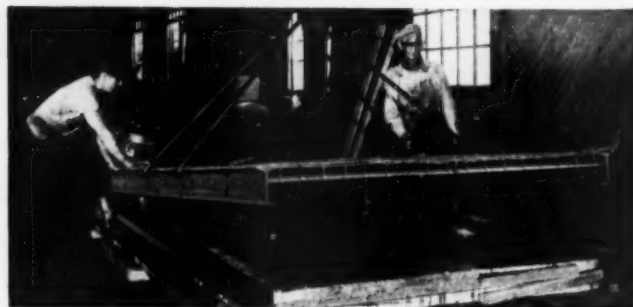


UNITED STATES STEEL HOUR—Televised alternate weeks—See your newspaper for time and station.

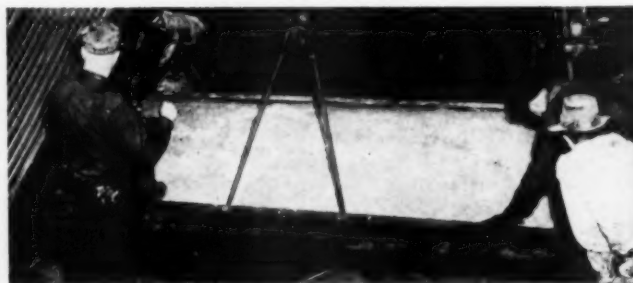
METAL PROGRESS; PAGE 206



Pre-cast roof sections of refractory concrete shown in place on completed core oven at Penn Steel Castings Company, Chester, Pa.



Plant personnel have put finishing touches on one cast panel. Moving into position is an I-beam frame with reinforcing for another panel.



Being fitted into place, a pre-cast monolithic section of refractory concrete shows this method's convenience of handling.

YODER *Multiple Rotary* SLITTERS



Big Convenience, yes...
but Savings are BIG, too!

Ask any owner of a Yoder slitter. He is apt to mention first the big *convenience* of being able at all times to supply his own needs in slit strands, from a relatively small stock of standard width coils. He no longer has to worry about ordering slit-to-width stock far in advance in order to anticipate production needs; changing production schedules he takes in his stride because he can meet unexpected needs for special widths on a few hours' notice. Since he is independent of outside slitting service he can buy his strip supply wherever he can get the best quality, price and delivery.

All of these conveniences may make him forget to mention the direct saving in dollars and cents which in most instances are big enough to pay for the slitter installation in a year or two, often even less.

The Yoder Slitter Book is a treatise on the mechanics as well as the economics of slitter operation, with time studies, cost analyses, coil handling, scrap disposal, and other useful data. It's yours for the asking.

THE YODER COMPANY
5595 Welworth Ave. • Cleveland 3, Ohio

Complete Production Lines

- ★ **COLD-ROLL-FORMING** and auxiliary machinery
- ★ **GANG SLITTING LINES** for Coils and Sheets
- ★ **PIPE and TUBE MILLS**—cold forming and welding



THERE'S HEAT THERE'S

FAHRALLOY

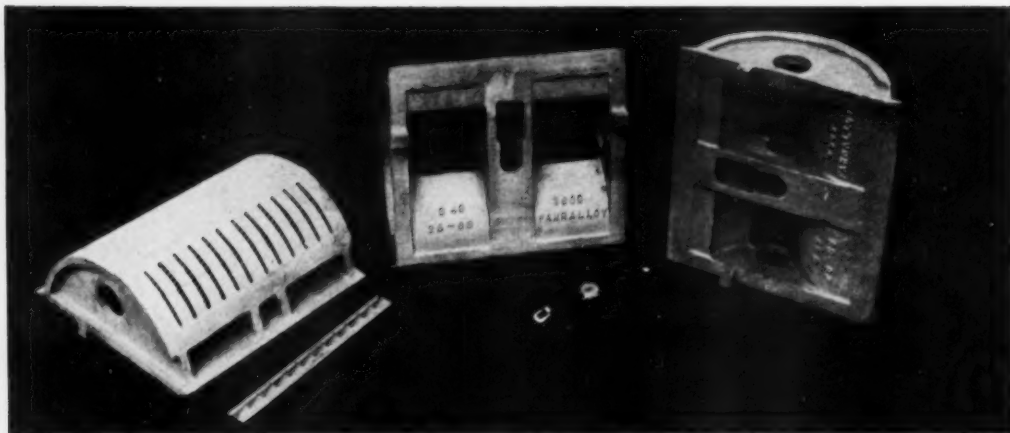
WHERE

WHERE THERE'S HEAT THERE'S FAHRALLOY

WHERE THERE'S HEAT THERE'S FAHRALLOY WHERE THERE'S HEAT THERE'S

FAHRALLOY...

*versatility means
better heat and corrosion
resisting alloy products for you*



Recuperator Liner for Cement Mill Cooler



Retort for Pit Type Carburizer

DURING the more than 20 years that Fahrallloy has been producing heat and corrosion resisting alloy castings for industry, versatility has been a keynote of the company's operations . . . versatility in design, in size, in composition to meet each individual need. Fahrallloy thinking has always been in terms of solving heat and corrosion problems. That's why Fahrallloy castings assure better service and longer life. When you have a problem that involves the toughest of high temperature service conditions, you can have complete confidence that you will find the solution at Fahrallloy.

CLARE CHARRON • 209 Curtis Building • Trinity 5-7633
DETROIT Area Representative



THE FAHRALLOY CO.

150th & Lexington Ave. — Harvey, Illinois

In Canada — Fahrallloy Canada, Ltd., Orillia, Ontario

High Vacuum Furnaces...

Built by People Who Run Them



There are a lot of things about vacuum furnaces that are hard to predict. You can't always work them out ahead of time on a *slide rule*. But time and again you can pull sound answers out of a backlog of *experience*.

The best training in designing and building vacuum furnaces is to run them — lots of them — all types — year after year.

That's just the kind of experience we have here at National. We've not only *built* more vacuum furnaces — but we have *operated* more than anyone else and over a longer period of time.

We think that's an important reason National's vacuum furnaces are engineered so closely to our customers' production requirements and why they have such a "trouble-free" reputation. NRC Vacuum Furnace bulletin now in preparation. Send your name for a copy.



National Research Corporation

Equipment Sales Subsidiary: NARESCO EQUIPMENT CORPORATION

160 Charlemont St., Newton Highlands 61, Mass.

OFFICES: PALO ALTO, CALIF. • CHICAGO • CLEVELAND • NEW YORK CITY • PHILADELPHIA



Here's why
it pays
to know your



FRANK LONG, HSM (Honeywell Supplies Man) in the Houston area, points out features of Brown thermocouple extension wire to **George Hubert** (right), Instrument Supervisor at Eastern States Petroleum Company, Houston, Texas . . . explains how the wide selection of wires lets you choose the type that fits any application requirements in your plant.

Personalized, expert service on all your pyrometer supplies problems is the keynote of the HSM Plan. Your HSM not only keeps you informed on the latest developments in Brown equipment and helps you select the types best fitted to your applications . . . but also helps you to buy all your supplies the most convenient and economical way.

Your nearby HSM will be glad to discuss how this plan can work in your own plant. Call him today at your local Honeywell office...he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

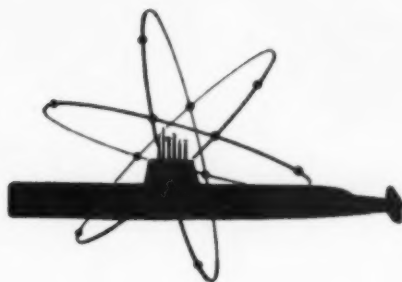
● **REFERENCE DATA:** Write for Pyrometer Supplies Buyers Guide No. 100-5, and for new booklet, "The HSM Plan for Purchasing Pyrometer Supplies."



MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS

First in Controls

For the FIRST time
**NUCLEAR
POWER**
is used for
PROPULSION



National Forge made many contributions to the "Nautilus." Among them were these two propulsion shafts supplied to the Electric Boat Division of General Dynamics Corporation, builders of the Navy's new "Nautilus."

● The U. S. S. "Nautilus" is expected to outmode all existing transportation power methods. We're proud of our share in equipping her — and we're proud of our long association with the United States Navy.

Over the years the Navy has come to rely on National Forge facilities: the skill and abilities of the metallurgists, heat-treat experts, and skilled machinists to turn out forgings to their exact specifications.

When next you need forgings, why not have them
NATIONAL-FORGED?

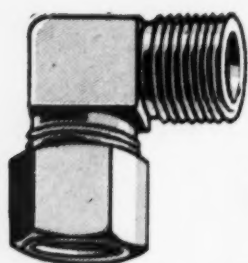
STEEL MAKERS ☆ FORGESMITHS
HEAT TREATERS ☆ MACHINISTS



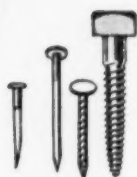
National Forge
AND ORDNANCE COMPANY

Irvine, Warren County, Pennsylvania

SEPTEMBER 1954; PAGE 211



INDUSTRIAL and
AUTOMOTIVE FITTINGS



COPPER NAILS and TACKS
BRASS LAG and CAP SCREWS



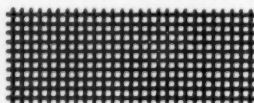
BRASS or BRONZE
BOLTS and NUTS



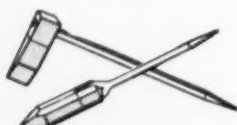
BRASS or COPPER
RIVETS and WASHERS



BRASS, COPPER, BRONZE
COTTER PINS



INDUSTRIAL WIRE CLOTH



SOLDERING COPPERS



BRASS STRAINER CLOTH



COPPER ANODES



BRASS or BRONZE WOOD
and MACHINE SCREWS



BRASS ESCUTCHEON PINS



SOLID or CORED BEARING BRONZE

*Need
anything
here?*

Chase *has* it—in wide variety.

You can be sure of getting
fast service and the finest in
brass and copper miscellaneous
items—when you call Chase.
Your nearest Chase Warehouse
is listed below.

CHASE NOW SELLS STAINLESS STEEL, TOO!

Chase 
BRASS & COPPER CO.

WATERBURY 20, CONNECTICUT • SUBSIDIARY OF KENNECOTT COPPER CORPORATION

FREE CHASE MOVIE

See "The Science of Making Brass," prize-winning documentary film. Now available on request to metal-working industries, technical associations, schools. Write any Chase office listed below.

The Nation's Headquarters for Brass & Copper

Albany†	Chicago	Denver†	Kansas City, Mo.	Newark	Pittsburgh	San Francisco
Atlanta	Cincinnati	Detroit	Los Angeles	New Orleans	Providence	Seattle
Baltimore	Cleveland	Houston	Milwaukee	New York	Rochester†	Waterbury
Boston	Dallas	Indianapolis	Minneapolis	Philadelphia	St. Louis	(sales office only)

SURFACE DECARBURIZATION PROBLEMS ... ELIMINATED

in
INVESTMENT CASTINGS
by **ARWOOD'S** new
Homocarb Furnace

Design Engineers

Arwood can investment cast intricate or simple shapes at great savings with the assurance of uniform quality — we can guarantee castings with .001" maximum decarburization.

Here's How

Arwood has pioneered again — recognizing the need for investment castings free of surface decarburization, Arwood is the first foundry to install carbon restoration equipment.

NOW...

Carbon and low alloy steel investment castings (1020, 3120, 4130, 4140 and 6150) can now meet all of the most exact metallurgical specifications — including freedom from surface decarburization.

Let ARWOOD help YOU

solve your production problem — improve your design — save you money — assure you top quality. Drop us a line to have one of our field engineers call on you and discuss how you can best utilize Arwood investment castings.

Ask for our booklet,

"Alloy Selection and Design for Precision Castings"

For the RECORD

These two mating units, pilot and anchor for aircraft clamp ring fastening screw, were previously milled from bar stock.

Using the carbon restoration unit, Arwood was able to meet the strict metallurgical specifications necessary to assure dependable performance.

ALLOY: 4140 (.001" Max. Decarb.)

HEAT TREAT: Double normalize, carbon restore, quench, temper

HARDNESS: Rc 25 Max

COST: 22.5% of machined cost

ARWOOD

PRECISION CASTING Corp.

73 WASHINGTON STREET B'KLYN 1, N. Y.

Plants: Brooklyn, N. Y. - Groton, Conn. - Tilton, N. H. - Los Angeles, Cal.

**MERRILL
MATERIALS HANDLING
DEVICES**

4
SIZES



LIFTING CLAMP



TWIN LIFTER



HAND GRIP



DRUM FILTER



DRAG CLAMP



4 SIZES



DRUM OPENER

MERRILL BROTHERS
56-31 ARNOLD AVENUE
MASPETH, N. Y.



helps

**customer save
\$24,000 a year!**

**9 Fixtures, Costing
Under \$2,000, Effect
Huge Annual Saving!**

When a manufacturer builds a good product . . .
that's interesting; BUT, when a manufacturer
builds a superior product that each year saves
the buyer 12 TIMES what he pays for it . . .

THAT'S NEWS! One of ALLIED METAL
SPECIALTIES' customers, a leading aeronau-
tical manufacturer, gave Allied the job of
designing and fabricating 9 fixtures for their
plant. Allied not only designed and built the
fixtures, they engineered a \$2,000 a month
saving into the customer's line. How many
fixtures, retorts, baskets, trays, racks, crates or
muffles have you bought that will save
you that kind of money?

**Why not get the whole story
from an Allied sales engineer?**

Just contact:



Allied

METAL SPECIALTIES, INC.

1505 Roland Heights Ave., Hampden Station, Baltimore 11, Md.

- Design and Fabrication
- All Metals and Alloys

Baskets - Crates - Trays
Racks - Fixtures
Muffles - Retorts

RARE EARTHS AND LOW CARBON STEELS

ROLLING MILL RECORD

SAE 1020	REGULAR	2# _T RAREMET
INGOT WEIGHT	8 000	8 000
BLOOM WEIGHT Before Conditioning After Conditioning	7900 72.00	DIRECT ROLLED
BILLET WEIGHT Before Conditioning After Conditioning	7130 6550	7420 7200
FINAL SIZE Before Conditioning After Conditioning	6500 6240	6970 6580
YIELD	78%	82.2%

The troubles of producing low carbon steels have been mainly confined to rolling and surface preparation.

Since production economies are necessary, it's important to know what marked improvements have recently been obtained by Rare Earths in steel production. Minimizing blooming mill cracking, less conditioning time per ton, and increased yields are some of the results already proven. More than 200 production heats of low carbon steel show production savings

which alert steel operators can use to advantage.

This recent progress further justifies economical rare earth additions for iron and steel. Commercially known as RareMeT Compound, it is conveniently packaged in ten pound containers.

Operating the world's largest rare earth deposits, Molybdenum Corporation of America welcomes requests for additional technical application data for specific problems. Complete and immediate response to inquiries is offered.

MOLYBDENUM

CORPORATION OF AMERICA

Grant Building

Pittsburgh 19, Pa.

Offices: Pittsburgh, Chicago, Detroit, Los Angeles, New York, San Francisco
Sales Representatives: Edgar L. Fink, Detroit; Brumley-Donaldson Co., Los Angeles, San Francisco
Subsidiary: Cleveland Tungsten, Inc., Cleveland
Plants: Washington, Pa., York, Pa.

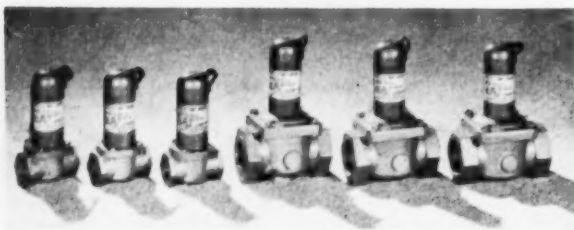


Burning Issues

Eclipse

Published by Eclipse Fuel Engineering Co.
Rockford, Illinois

Eclipse announces new line of
simpler and safer solenoid valves



Now in production at Eclipse is a completely new line of "DO" (diaphragm operated) solenoid valves for control of air, oil and fuel gases. With only two moving parts, these new valves assure dependable operation and low maintenance. They are pilot operated, with line pressure serving as the activating force. Minimum power is required to lift the solenoid plunger. Soft, synthetic rubber diaphragm assures positive shutoff. Seat and armature pilot plunger are stainless steel. Positively will not "jam." Easy to service without breaking line connections. Fine-grain aluminum bodies (individually tested under pressure) for gas and air service. Available in six pipe sizes, from 3/4 to 1 1/2 in. Line pressure up to 150 psi. Write for Bulletin M-500.

Complete line of Eclipse Lock-Tite safety valves now UL Approved

With UL Approval of the new large 4 and 6 in. sizes, Eclipse offers a complete line of UL and FM Approved Lock-Tite Safety Shutoff Valves for positive protection of gas combustion equipment under *any* and *all* conditions. With a choice of five actuating power units, Lock-Tites offer several combinations of multiple control... provide instantaneous shutoff for air, gas, or electrical failures. Convert *now* to this latest and finest *complete* protection system. Write for Bulletin M-302.



New motorized gas valve

Combine high capacity and soft-seat positive shut-off in sturdy, lightweight aluminum body. Job-proved, two-wire motor operator. Flange mountings with aluminum companion flanges furnished. For all commercial fuel gases. Sizes from 1 to 4 in. Write for Bulletin M-600.



Eclipse Fuel Engineering Co., 1127 Buchanan Street, Rockford, Illinois
Eclipse Fuel Engineering of Canada, Ltd., Toronto, Ontario

METAL PROGRESS; PAGE 216

Revco SUB-ZERO CHESTS

Temperatures
as low as
-95°F
BELOW ZERO

For Shrink Fits
Seasoning Gauges
and Precision Tools
For Laboratory Tests



REVCO RIVET COOLER Shown with 90 Rivet canisters... Model RSZ-503
Special Equipment Added To Meet Customer Requirements, if desired.

MODEL	CU. FT.	TEMP. FALL DOWN 70° RM	CAPACITY Inside (")			OUTSIDE Dimen. (")			Hermetic UNITS*
			L	W	H	L	W	H	
RIVET COOLER RSZ-503	5.0	-30°F	30	16	18	42	28	41	1/4 HP
SUB-ZERO SZH-153	1.5	-95°F	23	9	12 1/2	42	28	43	3/4 & 1/4
SUB-ZERO SZH-653	6.5	-85°F	47	15	16	60	28	43	3/4 & 1/4

*Fan Cooled; Refrigerant F22 and F12; Current 110/60 • WRITE TO:
REVCO INC. ... DEERFIELD, MICH.

A NECESSITY
For Every Shop

BINOCULAR MICROSCOPE

WITH STEREOSCOPIC
3-DIMENSIONAL VISION



The study of three dimensional objects requires stereoscopic vision, large depth of focus, high resolution of fine details, as well as large size of field. These fundamental features are all combined in the Binocular Microscope. The object is seen right side up in both directions.

SOME OF THE MANY USES

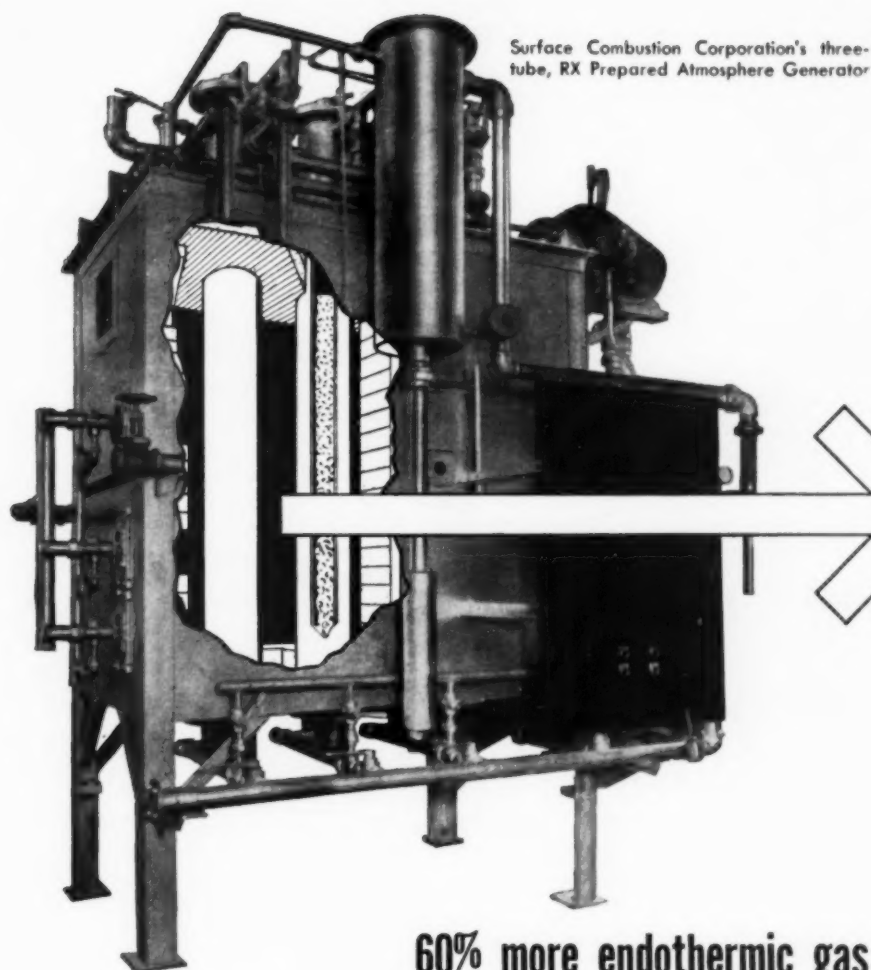
Balls and ball races for pits and flats, edges of razor blades and surgical knives, radio tube parts, watchparts, jewels; tools of all kinds; and control of surface finish in grinding and lapping operations.

WRITE FOR ILLUSTRATED FOLDER



Geo. SCHERR OPTICAL TOOLS, Inc.

200-PG LAFAYETTE STREET • NEW YORK 12, N. Y.



Surface Combustion Corporation's three-tube, RX Prepared Atmosphere Generator

**60% more endothermic gas
produced with NA22H retorts
without increasing generator size**

WHAT CAN THIS NEW ALLOY DO FOR YOU?

Prior to the installation of NA22H retorts, endothermic gas generators of the type shown above operated at approximately 1850F.

With generator design improvements to take advantage of the increased heat resistance of NA22H alloy retorts, these same generators now may be operated at temperatures from 2050F to 2100F . . . producing up to 60 percent more gas of greater uniformity.

The life of NA22H retorts, operating con-

tinuously at these temperatures, exceeds that of 35Ni-15Cr(HT) at 1850F.

This is just one of the many jobs that this new high temperature alloy is doing so well. What can it do for you?

You'll find other interesting case histories, operating data and the results of extensive tests in the new Blaw-Knox Booklet entitled, "NA22H." Write for it.

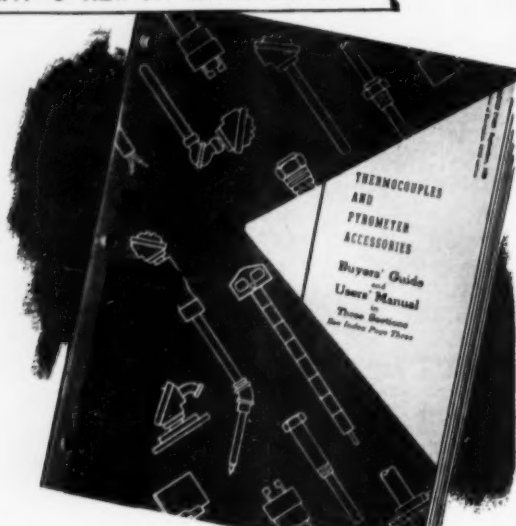


BLAW-KNOX COMPANY

NATIONAL ALLOY DIVISION

Pittsburgh 38, Pennsylvania

WHAT'S NEW AT BRISTOL...



Don't be without this free pyrometer reference book!

If you use pyrometers, this fact-filled 56-page booklet is a "must". Its three sections tell you quickly everything you want to know about thermocouples and all other pyrometer accessories.

Chock-full of money-saving ideas, informative illustrations, charts, and detail drawings, this well-indexed book does these three jobs:

HELPS YOU SELECT THE RIGHT THERMOCOUPLE, wire, and protecting tube for every installation. Complete information on all thermocouples and radiation pyrometers, with installation suggestions.

HELPS YOU KEEP THERMOCOUPLES ON THE JOB. Complete, well-tabulated descriptions of replacement parts and accessories, with simple ordering instructions.

HELPS YOU GET QUICK, ACCURATE CALIBRATION DATA. Calibration tables for all commonly used thermocouples, in Centigrade and Fahrenheit scales.

4.18

Mail the coupon today for your free copy!

The Bristol Company
106 Bristol Road
Waterbury 20, Conn.

Gentlemen:

Send me a free copy of your pyrometer
fact book.

Name _____

Firm _____

Address _____

City _____ Zone _____ State _____

For Your Best Buy in Electric Furnaces and Kilns Buy PERECO



Standard or Special Units for
Temperatures 450° to 5000° F.

Write Today

for get-acquainted folder
— or for quotation on
your specific need.



Pereny Equipment Co.

Dept. Q, 893 Chambers Rd., Columbus 12, Ohio

KING PORTABLE BRINELL

HARDNESS TESTER

Eliminates excessive material handling costs in routine and special Brinell hardness testing. The King Portable Brinell can be carried to the work, used in any position, and always puts an actual load of 3000 kg. on the 10mm. ball indenter.

This 27-lb. portable tester has a 4-in. deep throat and a gap 10 in. high. For larger pieces, the test head is easily removable for testing sections beyond the capacity of the standard base.



Throat—4" deep. Gap—10" high.
Weight—27 lbs.

Simple to operate, the tester is impossible to overload, and even with inexperienced operators will provide consistent accurate results well within the requirements of the Bureau of Standards.



**ANDREW
KING**

BOX 606 A
ARDMORE, PENNA.

Service life increased



The Zig Zag Wire Forming Machine is used to make springs for automotive seats and furniture.

60 times
with
AMPCO^{*}
METAL

THAT'S the story of the slide blocks used in Zig Zag Wire Formers. The service is tough—involves high speeds, severe shock loads. Roller bearing assembly lasted only four days, ordinary bearing bronze less than a month.

As a result, 25 Ampco Metal parts are used in the Zig Zag Wire Former. The company reports that in five years no Ampco Metal part has been replaced or adjusted in any machine.

Mr. Harry H. Norman, Chief Engineer of the Zig Zag Spring Company, Los Angeles, California, says that the long-wearing properties of Ampco Metal have contributed substantially to the success of their Spring Former.

Take a look at your wear problems. Perhaps Ampco Metal is the low-cost solution. Consult your nearest Ampco field engineer or write us for further information.



AMPCO METAL, INC.

Milwaukee 46, Wisconsin
West Coast Plant: Burbank, California

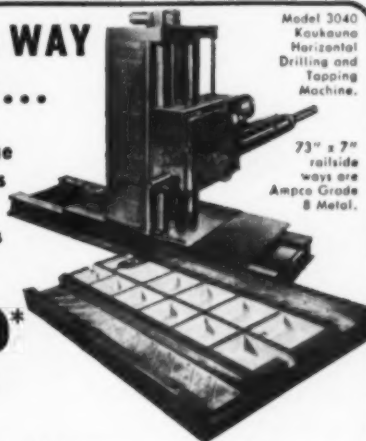
^{*}Reg. U. S. Pat. Off.

IT'S PRODUCTION-WISE TO AMPCO-IZE!

Here's the WAY
to do it...

Kaukauna Machine
Corporation fights
wear and high
bearing pressures

with
AMPCO^{*}
METAL



Model 3040
Kaukauna
Horizontal
Drilling and
Tapping
Machine.

73" x 7"
railside
ways are
Ampco Grade
8 Metal.

AMPCO Metal has high compressive strength — won't squash out. It has remarkable resistance to wear in all its forms — abrasion, corrosion, erosion, cavitation-pitting, etc. Ampco Metal gives you high impact and fatigue values — makes a superior bearing material. That's why it is often called "the Metal without an Equal."

Ampco Metal is easy to use — available in practically any form you need. You can get it in sand and centrifugal castings, sheet, plate, fittings, and fasteners. Also available as forgings, tubes, bars, extruded shapes, and welding electrodes and wire. Get complete information on any application from your Ampco field engineer or write us.

^{*}Reg. U. S. Pat. Off.



Ampco Metal, Inc.

MILWAUKEE 46, WISCONSIN
West Coast Plant, BURBANK, CALIFORNIA

mettle

LET AMPCO PROVE ITS METAL

Years of Service in the NAVY



EVANSTEEL

WIRE ROPE SOCKETS

Strength
Tested

Prior to World War II, the Navy used forged rope sockets exclusively.

But during the war, the Navy Department turned to EVANSTEEL cast steel sockets due to the shortage of forgings. After the war, the Navy again reverted to forged sockets—but it has found that EVANSTEEL cast sockets are just as serviceable, and so they are now on the same basis as forgings.

We've made over a million of these sockets, without one recorded service failure.

Modern engineering practice usually specifies EVANSTEEL Parts for maximum resistance to shock, abrasion, and breakage.

EVANSTEEL is a chrome-nickel-molybdenum alloy with a tensile strength after annealing that averages up to 60% greater than ordinary carbon steel.

EVANSTEEL Parts insure longer service life and lower material costs. EVANSTEEL permits the use of smaller and lighter sections without diminishing the safety factor.

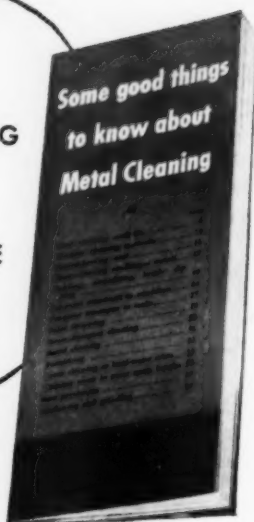
CHICAGO STEEL FOUNDRY CO.

Makers of Alloy Steel for over Forty-Five Years
KEDZIE AVE. & 37TH ST., CHICAGO 32, ILL.



See our
ROPE
SOCKET
BULLETIN
for full
Details

WHICH
METAL-CLEANING
JOBS
WOULD YOU LIKE
TO IMPROVE?



Listed below are some of the operations discussed in Oakite's 44-page handsomely illustrated booklet on Metal Cleaning. Please check the list. Then let us show you how Oakite methods can give you better production with greater economy.

Technical Service Representatives in
Principal Cities of U. S. and Canada

SPECIALIZED INDUSTRIAL CLEANING
OAKITE
MATERIALS • METHODS • SERVICE

OAKITE PRODUCTS, INC.
26H Rector St., New York 6, N. Y.

Tell me about Oakite methods and materials for the following jobs:

- ☐ Tank cleaning
- ☐ Machine cleaning
- ☐ Electrocleaning
- ☐ Pickling, deoxidizing
- ☐ Pre-paint treatment
- ☐ Zinc phosphate coating
- ☐ Paint stripping
- ☐ Steam-detergent cleaning
- ☐ Barrel cleaning
- ☐ Burnishing
- ☐ Rust prevention
- ☐ ALSO send me a FREE copy of your booklet "Some good things to know about Metal Cleaning".

Name _____

Company _____

Address _____

THE CONTROL OF QUALITY IN MELTING AND CASTING

THE CONTROL OF QUALITY IN THE PRODUCTION OF WROUGHT NON-FERROUS METALS AND ALLOYS—I.

Cloth. 4to. 88 pages, with 14 plates and numerous illustrations
in the text. Price \$2.50, post free.

CONTENTS

The Principles of Technical Control in Metallurgical Manufacture.
By A. R. E. Singer, B.Sc., Ph.D. (University of Birmingham)

The Control of Quality in the Production of Brass Ingots and
Billets.

By Maurice Cook, D.Sc., Ph.D., F.I.M. and C. L. M. Cowley, B.Sc.,
A.I.M. (Imperial Chemical Industries, Ltd., Metals Division)

The Control of Quality in Melting and Casting Copper and High-
Conductivity Copper-Base Alloys.

By J. Sykes, F.I.M. (Enfield Copper Refining Co., Ltd.)

The Control of Quality in the Casting of Zinc and Zinc Alloy
Rolling Slabs and Extrusion Billets.

By C. W. Roberts, B.Sc., A.I.M. and B. Walters, M.A. (Imperial Smelting
Corporation, Ltd.)

The Control of Quality in the Melting and Casting of Aluminum
Alloys for Working.

By R. T. Staples and H. J. Hurst (T. I. Aluminum, Ltd.)

The Control of Quality in Melting and Casting Magnesium Alloys
for Hot Working.

By R. G. Wilkinson, B.Sc. and S. B. Hirst, B.Sc.Tech. (Magnesium
Elektron, Ltd.)

General Discussion and Indexes.

INSTITUTE OF METALS

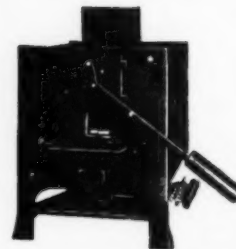
4 Grosvenor Gardens, • London, S.W.1

BUZZER HIGH SPEED Gas FURNACES

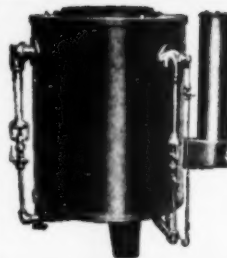
2400° F.

attained quickly with
"BUZZER" High Speed
Full Muffle Furnaces.

Designed primarily for high
carbon and alloy steels.



NO BLOWER or POWER NECESSARY
... just connect to gas supply



"BUZZER" Atmospheric
Pot Hardening Furnaces
assure even heat up to
1650° F.

Used for Salt, Cyanide and Lead
Hardening. Also adapted for
Melting Aluminum.

Send for the complete
"BUZZER" catalog today.

CHARLES A. HONES, INC.

123 South Grand Avenue, Baldwin, L. I., N. Y.



Invitation to Entrants

9th Metallographic Exhibit

Entries are invited in the 9th Metallographic Exhibit, to be held at the National Metal Exposition in Chicago the week of Nov. 1 through 5, 1954. Entries will be displayed to good advantage and awards will be given for the best micrographs as decided by a committee of judges.

Classifications of Micros

1. Toolsteels and tool materials
2. Stainless steels and heat resisting alloys
3. Other steels and irons, cast or wrought
4. Aluminum, magnesium, beryllium, titanium and their alloys
5. Copper, nickel, zinc, lead and their alloys
6. Metals and alloys not otherwise classified
7. Series showing transitions or changes during processing
8. Welds and other joining methods
9. Surface phenomena
10. Results by unconventional techniques (other than electron micrographs)
11. Slags, inclusions, refractories, cermets

Awards and Other Information

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of \$100, will also be awarded the exhibitor whose work is adjudged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's National headquarters in Cleveland.

All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1955 if so desired.

Rules for Entrants

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable. Photographic prints shall be mounted on stiff cardboard; maximum dimensions should be limited to 15 by 22 in. Heavy, solid frames are not permissible because of difficulties in mounting the exhibit. Entries should carry a label on the face of the mount giving:

Classification of entry
Material, etchant, magnification
Any special information as desired

The name, company affiliation and postal address of the exhibitor should be placed on the BACK of the mount.

Transparencies or other items to be viewed by transmitted light must be mounted on light-tight boxes wired for plugging into lighting circuit, and built so they can be fixed to the wall.

Entrants living outside the U.S.A. should send their micrographs by first-class letter mail endorsed "Photo for Exhibition—May be opened for customs inspection." To be acceptable as first-class mail the package should measure no more than 35 x 45 cm. (14 x 18 in.)

Exhibits must be delivered before Oct. 15, 1954, either by prepaid express, registered parcel post or first-class letter mail, addressed to:

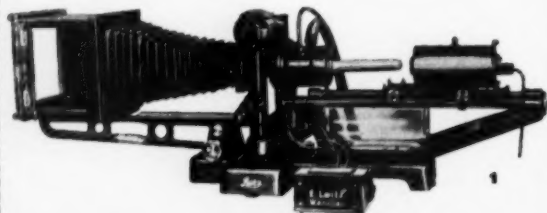
National Metal Exposition
International Amphitheater
43rd and Halsted Sts.
Chicago 9, Ill.

36th National Metal Congress and Exposition

Chicago, Ill.

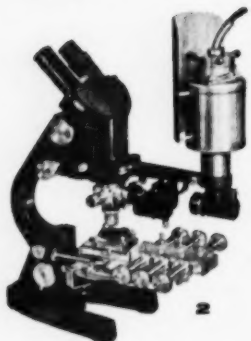
November 1 to 5, 1954

**LEITZ INSTRUMENTS
FOR THE
INDUSTRIAL LABORATORY**

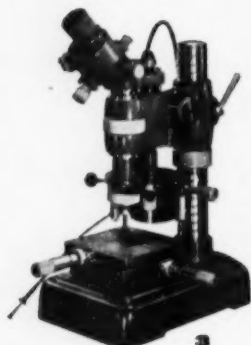


1. Leitz Dilatometer.
Designed for differential and absolute measurement of the expansion of metals and alloys. Photographically records expansion curves.

2. Leitz KPM Coal Petrography Microscope.
For the study of opaque material in polarized reflected light with special accessories for coal petrography.



3. Leitz Durimet.
Micro Hardness Tester designed for Vickers, Knoop and scratch hardness tests. Easy, quick and accurate operation. Load 15-500 grams.



4. Leitz Metallux. For grain size determinations and for the study of the character and type of inclusions of metals, ores, etc.



E. LEITZ, INC.
Distributor of the world-famous products of Ernst Leitz, Wetzlar, Germany

Leitz
microscopes
binoculars
Leica cameras
lenses

E. Leitz, Inc., Dept. MP
468 Fourth Avenue, New York 16, N. Y.

Please send me your brochure on the

Name _____

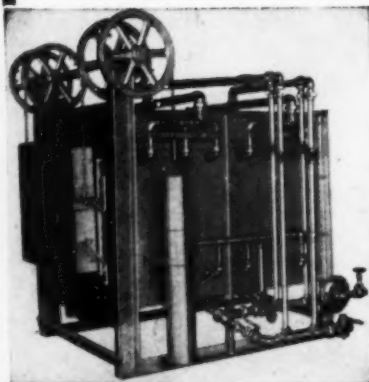
Company _____

Street _____

City _____

State _____

BLOWPIPES TO FURNACES A FULL LINE MADE by the PIONEERS



The AGF "SUPER" BLOW PIPE No. 1 is of a full line of varied sizes. Hardening, box carburizing, normalizing, annealing and many other adaptations of this furnace can be made at controlled temperatures ranging from 1200° to 2400° F. The top and bottom multiples of burners may be operated independently.



Write for Bulletin No. 200



AMERICAN GAS FURNACE CO.
1002 LAFAYETTE STREET ELIZABETH 4, N. J.

SQUARES, FLATS, HEXAGONS, OCTAGONS, BILLETS AND FORGINGS FOR

UP-TO-THE-MINUTE HY-TEN ALLOY STEELS

For over a century, Wheelock, Lovejoy & Company, Inc. has concentrated on the development of alloy and special steels with properties to meet individual needs. Today, WL has seven strategically located warehouses where you can get immediate delivery on any of the HY-TEN steels which have been developed by WL for unusual applications, plus many standard SAE and AISI grades. Every WL warehouse can supply these steels in rounds, squares, flats, hexagons, octagons, billets and forgings - every warehouse is staffed with expert metallurgists who are ready to assist you. Call on them.

Write today for your FREE COPIES of Wheelock, Lovejoy Data Sheets, indicating your title and company identification. It contains complete technical information on grades, applications, physical properties, tests, heat treating, etc.



134 Sidney St., Cambridge 39, Mass.

NOW AVAILABLE IN CLOTH-BOUND EDITION

Metals Handbook New 1954 Supplement

Order now a copy of the 1954 Supplement bound in red cloth to match your 1948 ASM Metals Handbook. The Supplement contains recent, authoritative information on all these subjects:

- Carbon and Alloy Steels
- Tool Steels
- Stainless Steels
- Heat-Resisting Alloys
- Nodular Cast Iron
- Aluminum
- Copper
- Magnesium
- Titanium
- Engine Metals
- Stress Concentration
- Shot Peening
- Ferrous Castings
- Brazed Joints
- Heat Treating
- Metal Cleaning
- Press Forming
- Machining
- Powder Metallurgy
- Steel Melting
- Nondestructive Inspection
- Metallography

This handsome 200-page volume contains 24 articles supplementing the 1948 ASM Metals Handbook. Prepared by 22 ASM technical committees, it has 326 illustrations, 155 tables. It makes a worthy addition to your technical library, one you'll refer to often.

For complete details of contents, see your July 15, 1954, issue of Metal Progress . . . which contains all the articles now being offered in this cloth-bound edition. Price is \$4.00 to ASM members, \$5.00 to non-members.



American Society for Metals
7301 Euclid Avenue, Cleveland 3, Ohio

Rush me a copy of the cloth-bound 1954 Supplement to the ASM Metals Handbook.

Name

Company

Address

City State

Member of ASM Chapter

☐ \$4.00 enclosed—ASM member

☐ Bill me

☐ \$5.00 enclosed—non-member

☐ Bill my company

Metal Progress

Taylor Lyman, Publisher

A. P. Ford, Sales Manager

George H. Loughner, Production Manager
7301 Euclid Ave., Cleveland 3—UTah 1-0200

PUBLISHED BY AMERICAN SOCIETY FOR METALS, 7301 EUCLID AVE., CLEVELAND 3, OHIO—W. H. EISENMAN, SECRETARY



District Managers

John F. Tyrrell and John B. Verrier, Jr.

55 W. 42nd St., New York 18—Chickering 4-2713

Ralph H. Cronwell

964 W. Villa Drive, Des Plaines, Ill.—Vanderbilt 4-1206

Don J. Billings

7301 Euclid Ave., Cleveland 3—UTah 1-0200

• Index to Advertisers •

Acheson Colloids Corp.	36
Ajax Electric Co.	51
Ajax Electrothermic Corp.	79
Ajax Engineering Co.	165
Aldridge Industrial Oils, Inc.	60, 62
Allied Metal Specialties, Inc.	214
Allied Research Products, Inc.	144
Alloy Engineering & Casting Co.	193
Almco Div.	55
Alpha Corp.	62
Alvey-Ferguson Co.	25
American Brass Co.	135
American Cast Iron Pipe Co.	204
American Chemical Paint Co.	138
American Gas Association	159
American Gas Furnace Co.	222
American Machine & Metals, Inc.	12
American Metalast Mfg. Corp.	29
American Non-Gran Bronze Co.	63
American Rack Co.	53
American Roller Die Corp.	128
American Society for Metals	

28, 191, 195, 202, 221, 223	
Ames Precision Machine Works	168
Ampco Metal, Inc.	219
Anglo-American Scientific	200
Armour & Co., Ammonia Div.	137
Arwood Precision Casting Corp.	213
Ashworth Brothers, Inc.	23
Association of Iron & Steel Engineers	47

Baker & Co., Inc.	196
Baldwin-Lima-Hamilton	205
Barber-Colman Co.	
Wheeler Instruments Div.	15
Bausch & Lomb Optical Co.	112D
Blaw-Knox Co.	217
Bell & Gossett Co.	160B
Bel-Ray Co., Inc.	62
Bethlehem Steel Co.	155, 183
Bigelow-Liptak Corp.	151
Boder Scientific Co.	56
Bowser Technical Refrigeration	150
Branson Instruments, Inc.	57
Bridgport Brass Co.	177
Bristol Co.	218
Bundy Tubing Co.	75
Buehler, Ltd.	52B

Cambridge Wire Cloth Co.	148
Cannon-Muskegon Corp.	24
Carborundum Co.	141
Carl-Mayer Corp.	29
Carlson, Inc., G. O.	146
Chase Brass & Copper Co.	212
Chemical Corp.	19
Chicago Steel Foundry Co.	219
Cincinnati Milling Machine Co.	4
Cities Service Oil Co.	171
Clark Instrument Co.	198
Cleveland Crane and Engineering Co.	61
Cleveland Metal Abrasive Co.	53
Climax Molybdenum Corp.	19
Cold Metal Products Co.	32B
Columbia Tool Steel Co.	25
Consolidated Vacuum Corp.	37
Cooley Electric Mfg. Corp.	60
Copper & Brass Research Association	166-167
Copperweld Steel Co.	Back Cover
Cruetite Steel Co. of America	65, 161, 185

Deakin & Son, J. Arthur	56
Dempsay Industrial Furnace Corp.	60
Despatch Oven Co.	136
Detroit Testing Machine Co.	23, 56
Dow Chemical Co.	163
Dow Furnace Co.	156
Driver Harris Co.	189
Du-Lite Chemical Corp.	55
duPont de Nemours & Co., Inc.	201
Dursley Co.	182

Eastman Kodak Co.	133
Ellipse Fuel Engineering Co.	216
Eksrand & Tholand, Inc.	64
Electric Furnace Co.	Inside Back Cover

Electro Alloys Div. American Brake Shoe Co.	2
Electro Metallurgical Co. Unit of	
Union Carbide and Carbon Corp.	127
Engineered Precision Casting Co.	63
Enthone, Inc.	175
Erico Products, Inc.	63
Fahrerley Co.	208
Finkl & Sons Co., A.	181
Firth Sterling, Inc.	71
General Alloys Co.	112C
General Electric Co.	6-7
Gordon Co., Claud S.	194
Great Lakes Carbon Corp.	70
Great Lakes Steel Corp.	73
Gulf Oil Corp.	38-39

Handy & Harman	77
Harshaw Scientific Div.	
Harshaw Chemical Co.	72
Haynes Stellite Co., Unit of	
Union Carbide & Carbon Corp.	145
Hays Corp.	60
Hevi Duty Electric Co.	26-27
Holcroft & Co.	32A
Hones Inc., Chas. A.	220
Hooker Electrochemical Co.	157
Hoover Co., Die Casting Div.	63
Hoskins Mfg. Co.	203
Houghton & Co., E. F.	45

Imperial Rack Co.	53
Industrial Heating Equipment Co.	58
Industrial Rack Co.	53
Institute of Metals	220
International Nickel Co.	76, 112A
Ipsen Industries, Inc.	32

Jelliff Mfg. Corp., C. O.	55
Jessop Steel Co.	64A
Jet Combustion, Inc.	164
John-Manville	64B
Kemp Mfg. Co.	139
King Co., Andrew	218
Kinney Mfg. Div. of N.Y. Air Brake Co.	202

Lakeside Steel Improvement Co.	57
LaSalle Steel Co.	192
Latrobe Steel Co.	33
Lebanon Steel Foundry	172
Leitz, Inc., E.	222
Lindberg Industrial Corp.	10-11
Lindberg Steel Treating Co.	57
Little Falls Alloys	64
Loftus Engr. Corp.	34-35
Lucas-Milhaupt Co., Inc.	31
Lumite Div.	206

Magnetic Analysis Corp.	56
Malayan Tin Bureau	22
Manhattan Rubber Div.	
Raybestos-Manhattan, Inc.	54
Martindale Electric Co.	196
Maurath, Inc.	63
Meriam Instrument Co.	57
Merrill Bros.	214
Metalwash Machinery Co.	58
Metals Disintegrating Co., Inc.	186
Midvale Co.	169
Minneapolis-Honeywell Regulator Co.	
(Industrial Division)	142-143, 210
Misco Fabricators, Inc.	188
Mitchell-Bradford Chemical Co.	170
Molybdenum Corp.	215
Mueller Brass Co.	158

National Carbon Co. Unit of	
Union Carbide & Carbon Corp.	66-67
National Forge & Ordnance Co.	211
National Rack Co.	53
National Research Corp.	209
Nitrogen Division	
Allied Chemical & Dye Corp.	162
Norton Co.	18, 30

Oakite Products, Inc.	220
Olsen Testing Machine Co., Tinius	78
Park Chemical Co.	69
Parker Stamp Works, Inc.	60
Pennsylvania Salt Mfg. Co.	147
Pennys Equipment Co.	218
Peterson Steels, Inc.	16
Pressed Steel Co.	129
Production Specialties, Inc.	53, 54
Puritan Mfg. Co.	53

Radio Corp. of America	184
Raybestos-Manhattan, Inc., Manhattan	54
Republic Steel Corp.	153, 199
Revere Copper & Brass, Inc.	131
Reveco, Inc.	216
Reynolds Metals Co.	187
Richards Co., J. A.	61
Rigidized Metals Corp.	64
Rockwell Co., W. S.	154
Roll Alloys, Inc.	179
Roll Formed Products Co.	62
Rolock, Inc.	149
Ryerson & Son, Inc., Jos. T.	80

St. Joseph Lead Co.	46
Salem-Brosius, Inc.	160A
Sargent & Wilbur, Inc.	134
Saunders & Co. Alexander	17
Scherr Co., Inc., George	216
Schell Tool & Die Corp.	61
Selas Corp. of America	46
Sel-Rex Precious Metals, Inc.	54
Sentry Co.	132
Sessions & Son, J. H.	62
Sinclair Refining Co.	20
Solvental Chemical Products, Inc.	5
Spencer Turbine Co.	173
Standard Alloy Co., Inc.	140
Standard Steel Treating Co.	60
Stawson Corp.	59
Star Stainless Screw Co.	62
Sun Oil Co.	14
Superior Steel Corp.	52A
Surface Combustion Corp., Inside Front Cover	
Swift Industrial Chemical Co.	55
Sylvania Electric Products, Inc.	174

Taylor Sons & Co., Chas.	42
Technic, Inc.	54
Tennant Sons & Co., Stamping	180
Timken Roller Bearing Co.	43
Torsion Balance Co.	56

Union Carbide & Carbon Corp.	66-67, 127, 145
United Chromium, Inc.	68
Upton Electric Furnace Co.	59
U.S. Rubber Co.	8-9
U.S. Steel Co.	16A-B-C-D

Vanadium Corp.	52
Vacuum Metals, Inc.	50

Walta Furnace Co.	178
Waukegan Engineering Co.	31
Waukegan Foundry Co.	44
Western Products, Inc.	59
Westinghouse Electric Corp.	40-41, 152
Wheeler Instruments Div.	
Barber-Colman Co.	15
Wheelock, Lovejoy & Co., Inc.	222
White Metal Rolling & Stamping Corp.	61
Wilson Mechanical Instruments Div.	
American Chain & Cable	160
Wiretex Mfg. Co., Inc.	58
Wyckoff Steel Co.	190
Wyman-Gordon Co.	74

Yoder Co.	207
Young Bros.	176
Youngstown Sheet & Tube Co.	197
Youngstown Foundry & Machine Co.	49

Zirconium Corp.	194
-----------------	-----



EF

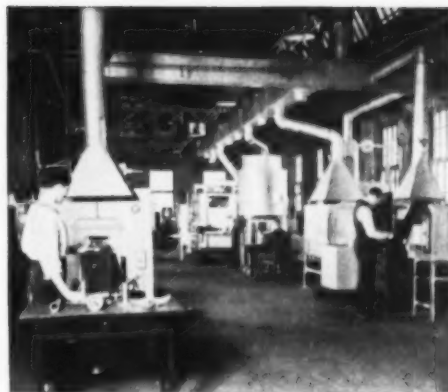
RESEARCH DEPARTMENT
available to
PRODUCERS and PROCESSORS
of metals and metal products

● The EF research department is equipped with gas-fired, oil-fired and electrically heated continuous and batch units including, — continuous wire mesh furnaces; — endothermic and exothermic special atmosphere generators; — forced circulation bell furnaces; — a continuous roller hearth furnace for treating commercial widths of ferrous and non-ferrous strip; — and other equipment.

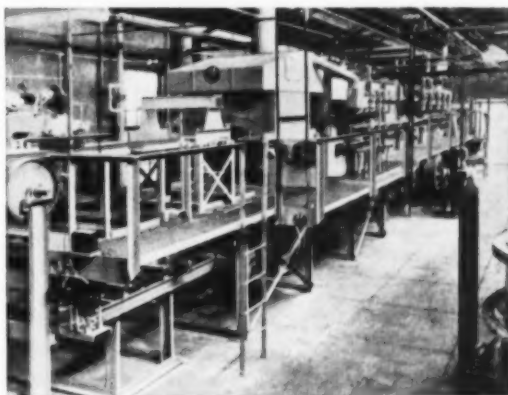
Consequently, — from test runs — we can determine accurately the combination of temperature, time cycle, atmosphere and other factors needed to produce the exactly desired results, — assuring — in advance — the efficient performance of EF furnaces *fully up to specifications.*

Many large companies have drawn liberally upon this department in developing new products, and new techniques. Our facilities are available to YOU also — for YOUR research or development work, either gratis or for a moderate fee, depending upon the nature of the experiment. We will be glad to schedule time for your technicians.

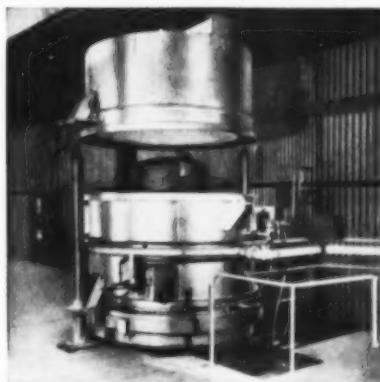
Write today for our 12-page booklet, "Research Facilities". It describes the equipment we can place at your disposal.



General view of the research department showing several of the continuous and batch type experimental furnaces.



View of combination gas-fired and electric continuous furnace equipped with flame preheating burn-off or oxidizing section and controlled heating, soaking and cooling zones, for producing various surface conditions on strip.



Direct gas-fired forced circulation bell type furnace for processing wire, rod, strip and other products.

EF

Gas-Fired, Oil-Fired and Electric Furnaces
for any Process, Product or Production

THE ELECTRIC FURNACE CO.

WILSON ST. at PENNA. R. R.

Salem - Ohio

Canadian Associates • CANEFCO LIMITED • Toronto 1, Canada

DO YOU HAVE ANY QUESTIONS ABOUT LEAD-TREATED STEELS?

QUESTION

What is a lead-treated alloy steel ?

What special advantages does the lead addition impart to the alloy steel ?

In what qualities and forms are lead-treated alloy steels available ?

Does the lead addition influence in any way the heat treatment of alloy steels ?

Does the lead addition affect the mechanical properties of alloy steels ?

What are the machining properties of a lead-treated alloy steel. ?



Where are lead-treated alloy steels most suitably applied ?

ANSWER

It is an alloy steel made to any standard specification but with the addition of lead, usually in the range of 0.15—0.35%.

It improves the machinability, increases productivity and reduces costs.

Any Aristoloy steel can be made with a lead addition and supplied in any of our standard sections.

No. A lead-treated alloy steel responds to heat treatment in exactly the same way as its counterpart without lead.

The addition of lead to any steel does not materially affect its mechanical properties.

Lead-treated Aristoloy steels cut more freely than standard alloy steels, and yield a better surface finish even at higher cutting speeds. Of equal, if not greater, importance is the fact that these steels are less severe on the cutting tools.

Lead-treated Aristoloy steels show to greatest advantage when subjected to complicated or extensive machining operations, or *where it is necessary to machine in the higher ranges of tensile strengths.*

COPPERWELD STEEL COMPANY (Steel Division) WARREN, OHIO